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THE ROENTGEN STUDY OF COLONIC DIVERTICULA*

BY JAMES T. CASE, M.D.,

Surgeon, Battle Creek Sanitarium; Professor of Roentgenology, Northwestern University Medical School (Chicago)

BATTLE CREEK, MICHIGAN

COLONIC diverticulosis constitutes one of the most interesting and spectacular findings in the roentgen study of the colon by means of opaque media. In diverticulitis surgeons find one of the most interesting phases of modern surgical pathology; the pathology of diverticulitis is really a modern development although recognized and described by Cruveilhier[6] nearly eighty years ago (1849) and by Virchow[17] seventy-five years ago (1853). Graser[9] in 1898 described the formation of diverticula of the intestine and showed the great frequency with which diverticula occur. During the next few years Fischer,[7] Beer[3] and Moynihan[12] made important contributions, and in 1907 Mayo and Wilson[11] reported the first series of five American cases in which operation had been performed.

The first really complete treatise on colonic diverticula was that of Telling[15] in 1908. The first operated case demonstrated roentgenologically before operation was published by Abbé[1] in 1914, the roentgen-ray examination having been made by L. T. LeWald. The next publications on this subject were by the writer[5] at Battle Creek and by the late Russell D. Carman, working independently. Both papers were published in February of 1915. Since then the literature of the roentgenological and clinical aspects of colonic diverticula has reached considerable proportions.

CLASSIFICATION

Various classifications have been proposed. Telling's classification, based on the pathological changes, divides the manifestations of colonic diverticula into mechanical and inflammatory, the mechanical including the formation of fecal concretions in the sacs, torsion of the diverticulum and lodgment of foreign bodies; the inflammatory changes including diverticulitis proper (acute, gangrenous, subacute, chronic and latent).

Many diverticula, especially those situated in the stomach, duodenum and jejunoileum show no signs of inflammatory reaction and are therefore not really entitled to a descriptive word implying inflammation. In 1914 the writer proposed the term "diverticulosis" for this condition. It has also been proposed by other authors including Spriggs and Marxer[14] and de Quervain.[13] However, even in the upper alimentary tract certain of these diverticula undergo active inflammatory changes in and about the sacs and merit the term "diverticulitis." Particularly in the colon, most of all in the sigmoid colon, we find the condition of "diverticulitis."

We have therefore employed as practical

* Read by Dr. Upson in the absence of the author at the Twenty-ninth Annual Meeting of the AMERICAN ROENTGEN RAY SOCIETY, Kansas City, Mo., Sept. 25–28, 1928.

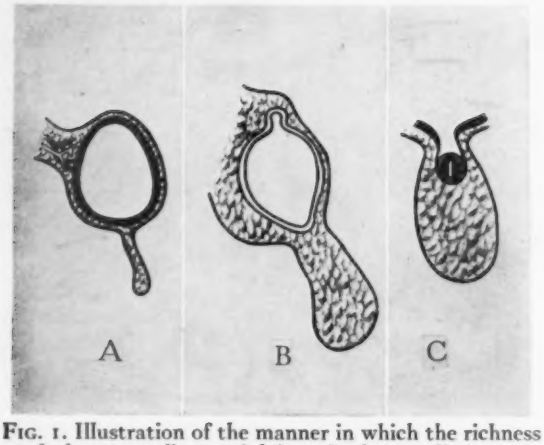

Fig. 1. Illustration of the manner in which the richness of the appendices epiploicae in fat predisposes to diverticulum formation. (A) Shows the transverse section of the colon in a thin individual showing the relationship of an epiploic appendix to the subserous fat. (B) Shows a similar condition in a very obese individual with a diverticulum is process of formation. (C) Shows a diverticulum pouching into the epiploic appendage and containing a fecal concretion. (Modified from Bland-Sutton.)

clinical terms the words "diverticulosis" and "diverticulitis." "Diverticulitis" has been subdivided to include cases of (1) the "enterospasm type," (2) the "hyperplastic type" and (3) the "pseudo-appendicitis type."

Cases classified as diverticulosis include that relatively large group with few or numerous small hernial protrusions in the wall of the bowel demonstrable on roentgen examination, but not producing any symptoms referable to the diverticula.

The "enterospasm type" includes that group of cases in which the diverticula even though numerous are scattered, and where the symptoms are apparently only those of enterospasm, kept up by continuous renewal of intestinal irritation from the retained contents of the diverticular sacs.

The "hyperplastic type" refers to those cases in which the diverticula are situated fairly close together, especially in the region of the pelvic colon where on account of their grouping the peridiverticular inflammatory reaction, and the consequent production of connective tissue, tends to produce a tumor with resulting organic obstruction.

In the "pseudo-appendicitis type" one or more of the diverticula, even where the saccules are not generally characterized by peridiverticular inflammation, undergo an acute inflammatory process analogous to that occurring with acute appendicitis. We may include in this group inflammation of an epiploic tag. Telling called attention to the frequency with which the diverticula are covered over by the fatty epiploic appendages in such a way as to effectually hide the majority of the saccules from discovery by external examination of the bowel in the opened abdomen (Fig. 1). An inflammatory process in one of these diverticula covered by a fatty intestinal appendage may result in an appendical epiploitis. In our surgical service we have operated on several cases where a single tag was thus involved, cure resulting in such cases from removal of the offending epiploic appendage.

The differentiation between diverticulosis and diverticulitis is really based largely upon clinical grounds. It is true that in certain cases, the roentgenological appearances are such as to suggest the inflammatory or non-inflammatory nature of the lesion; but the differentiation is greatly aided by a knowledge of the clinical symptoms.

Just how large a group of cases will fall under the heading of diverticulosis depends on one's conception of what constitutes symptoms. The mildest group under the diverticulitis classification is made up of the enterospasm type of cases, and it is difficult to draw a sharp line of differentiation between the cases of purely symptomless diverticulosis and those of the enterospasm type of diverticulitis.

The early symptoms of the group of cases of diverticulitis characterized by spasm of the colon are common to the early stage of many abdominal diseases: vague abdominal distress, slight intestinal upsets, discomfort in the abdomen particularly on the left side but occurring also on the right. A well-developed diverticulitis causes attacks of pain and tenderness over the entire colon, usually more marked in the left lower quadrant but also frequently combined with distress in the right lower quadrant. Bladder irritability is frequent and associated with tenderness over the middle of the lower abdomen. This abdom-

inal tenderness is very commonly encountered and is often accompanied by muscular rigidity. Colics are not rare and when present tend to recur frequently. Moderate irregular fever may come on in attacks through a period of years. Leucocytosis may occur, with or without fever. Constipation is usual although occasionally alternating with diarrhea. Examination of the stools in this group seldom reveals the presence of blood, although in the cases of peridiverticulitis with tumor about one-fifth of the patients show blood in the intestinal excreta.

According to the predominance of certain symptoms, all cases may be classified as above described. In diverticulitis with enterospasm predominating, there is a notable absence of signs of tumor or obstruction, or an acute inflammatory development with suppuration leading to the necessity of urgent surgery. Abdominal distention, colicky pains, especially across the abdomen, fever, hyperleucocytosis and other signs pointing to either the obstructive or the pseudo-appendicitis type of lesion are absent, but there are the ordinary signs of chronic colitis.

In the pseudo-appendicitis type, the patient, usually with a long history of diverticulitis of the spastic type, suddenly develops acute symptoms demanding urgent attention. These symptoms should be distinguished from the true left-sided appendicitis which occurs only with nonrotation of the colon or in cases of true transposition of the viscera, but otherwise the complaints and signs are quite similar: hyperleucocytosis, fever, pain, tenderness usually over the left side, muscular rigidity, constipation occasionally alternating with diarrhea, localized peritonitis,—all suggesting the need of surgical intervention, at least for drainage of the infected area.

In the obstructive type, the symptoms are those of a long-standing constipation with perhaps a history of several acute attacks simulating the so-called left-sided appendicitis but with progressively obstinate constipation, the development of colicky pains, notably across the transverse colon and in the right side of the abdomen, small, frequent stools or impulse to move the bowels without good results, and usually a palpable tumor. This tumor thought to be due to bacterial inflammation of the intestinal wall, is generally described as sausage-shaped and exhibits intermittency as one of its important characteristics. The appearance of a mass and its subsequent disappearance, with reappearance within a few days, is one of the most reliable signs of perisigmoiditis due to diverticulitis. This tumor may be felt either abdominally, rectally, or on a combined examination. There may occur a rare case of right-sided diverticulitis indistinguishable from appendicitis and perhaps even suggesting gall-bladder disease; here, as in other parts of the colon, the symptoms will depend somewhat on the exact situation of the inflamed diverticula.

TECHNIQUE OF EXAMINATION

The sigmoidoscope and stool examination seldom give decisive information in cases of diverticulitis. We have read that it is possible in occasional cases by means of sigmoidoscopy to visualize the orifice of one or more of the diverticula, but the use of the sigmoidoscope is dangerous in the presence of diverticulitis. Trauma of all kinds must be avoided in cases of suspected diverticulitis. Even the surgeon at operation must be gentle in handling the diverticulum-bearing bowel.

The roentgen-ray study is really the only means of establishing a diagnosis of diverticulosis and it is the most important method of detecting diverticulitis.

Carman thought it best to employ the opaque enema for demonstrating the diverticula, while we have laid particular stress on the value of the roentgen studies carried to the fourth or fifth day after the opaque meal examination, combined with the barium enema, as giving the maximum amount of information in these cases.

It is now recognized as necessary to employ both the opaque meal and the enema (Figs. 2 and 3), and to take advantage of both screen and roentgenographic study. It is not enough simply to demonstrate residues in the diverticula, although this of course constitutes the best proof of the condition; we must also obtain all available data having a bearing on the

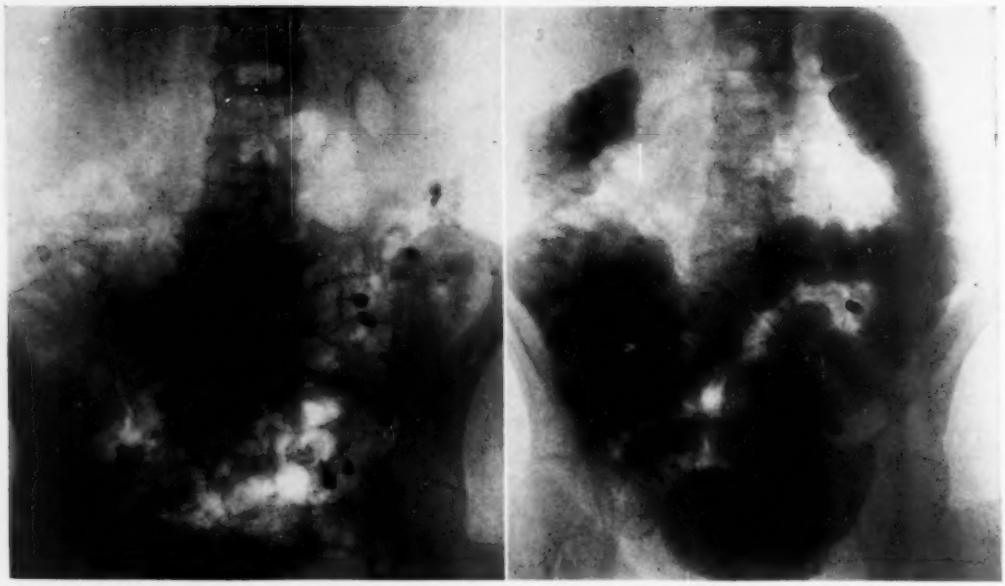

Fig. 2. On the left, some colonic diverticula still visualized at the end of seventy-two hours following the barium meal and persisting in spite of cleansing enemas. On the right, the same diverticula shown in relation to the colon after the injection of the opaque enema.

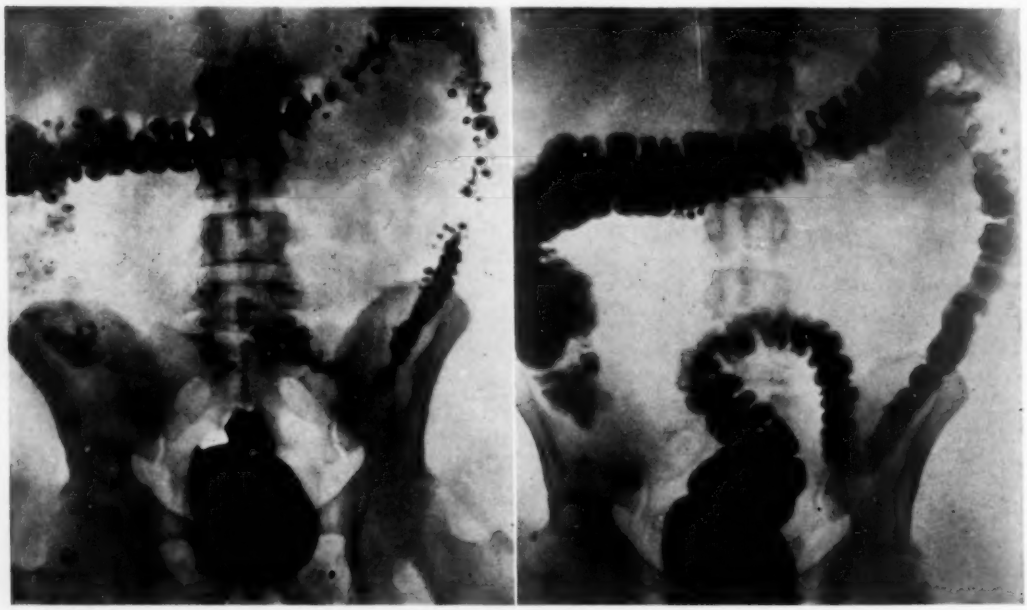

Fig. 3. Left—Roentgenogram fifty hours after barium meal showing numerous colonic diverticula without obstruction as is shown by the marked rectal stasis. Right—The same colon filled by enema showing the relation of the diverticula to the colon and further demonstrating the lack of an organic narrowing.

diagnosis, the prognosis and the method of treatment. Some authors claim that in occasional cases the diverticula may defy roentgenological demonstration, but by the technique which we shall describe it will be possible to show some sign of diverticulitis, even when the diverticula cannot be definitely identified.

The basic facts underlying the roentgenological interpretation of diverticula are as follows: The normal colon shows haustration. The haustral segments are

regular and symmetrical except perhaps at the flexures. This segmentation is due to contraction of the muscle fibers* and affects all layers of the bowel except the peritoneal coat, which marks the notches between the haustral sacs but does not enter into their formation. The haustra are normally present in a roentgenogram of the colon whether following the meal or following the opaque injection. In certain states of colitis the haustral formation is inhibited so that the colonic outline is smooth; the more severe the colitis, the more conspicuous the absence of haustra in the roentgenogram. Following the passage of an opaque meal through the colon, one observes in cases of diverticulosis small rounded shadows, evidently residues of the opaque salt in the affected areas. These rounded shot-like residues may be scattered throughout the large bowel but are usually more numerous near the ileopelvic junction; they may be confined to that area. These rounded shadows usually occur in groups, but wherever they occur they maintain the same relation to each other and to the colon when visualized by its gas content or by the opaque enema.

The diverticula are best seen on the second or third day after the opaque meal when by careful screen study, especially during manipulation of the iliac and pelvic colon, one may detect their presence. These shadows sometimes appear shortly after the opaque meal reaches the affected segment but it most often happens that they are not recognized definitely until the second or third day, after most of the opaque material has been evacuated. It is at this moment especially illuminating to administer an opaque enema, carefully studying the rounded shadows in relation to the enema-filled colon. This study may be carried out roentgenoscopically, though roentgenograms are especially graphic, and sometimes stereoroentgenograms furnish the most decisive and spectacular evidence.

The diagnosis may be made frequently, if not almost always, by means of the enema alone but it is important that in such cases the enema should be retained for half an hour or longer. It usually occurs that in these cases the patient is able to expel the enema only from the rectum and lower pelvic colon, the remainder being retained. Screen or film studies half an hour to an hour later, or even ten or twelve hours later, will frequently demonstrate the filling of the diverticula in cases where they did not show immediately after the enema.

In the first case reported (Abbé[1]), examined by LeWald, the diverticulum retained bismuth up to the tenth day. In a case of multiple colonic diverticula reported by the writer[5] in 1915, they were seen still filled on the sixteenth day. Much longer retention than this has been reported by several observers. As above stated, however, it is not sufficient merely to show the diverticula; it is important to obtain information on several other points, particularly the question of peridiverticular induration, fistulae, obstruction, possible associated carcinoma and adhesions of the small bowel, determination of whether the case is advanced, and in early cases to decide whether or not there exist symptoms which correspond to the prediverticular state, described by Spriggs and Marxer,[14] and which will be discussed in later paragraphs of this paper.

If one definitely suspects a diverticulitis but finds no sign of the diverticula with the opaque meal, it may be helpful to give the maximum physiologic dose of belladonna or atropine during twenty-four to forty-eight hours. Then the usual preparation of the colon by cleansing enemas will considerably increase the chance of demonstrating the diverticula by the opaque enema. The use of the antispasmodic will also aid in differentiating between an organic stricture and a spastic state, a differentiation very important to make but not always easily accomplished in diverticulitis.

The development of the roentgenology of colonic diverticula may be described under three headings. The first notable step was the detection of the diverticula themselves (LeWald, Carman and Case). The second important advance was initiated by George and Leonard[8] who in March, 1919, called attention to an appearance of

*Thaysen[16] declared in 1916 that haustral segmentation is a contraction phenomenon which is not produced by a distention of the gut and is not due to the shorter length of the teniae as compared with the length of the colon. The haustra are formed by local contractions of the circular musculature.

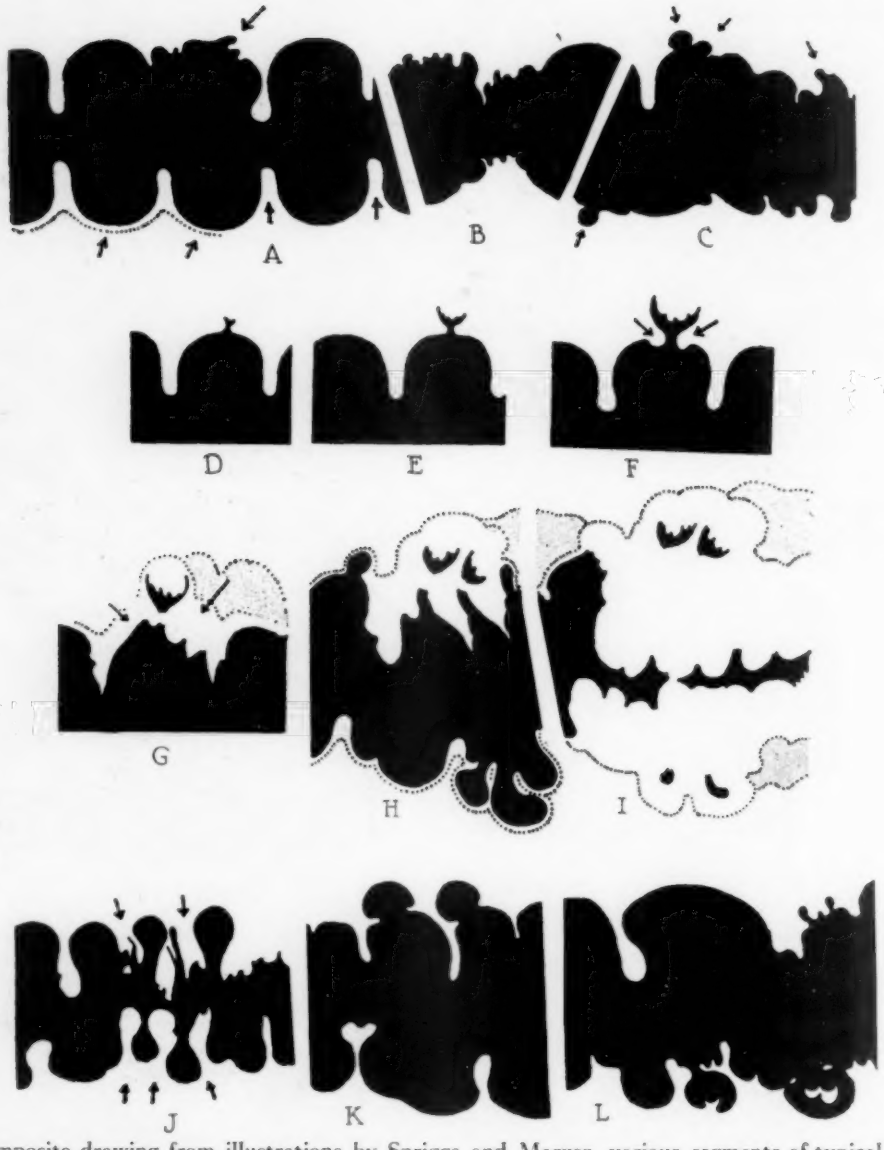

Fig. 4. Composite drawing from illustrations by Spriggs and Marxer, various segments of typical colon being lettered from A to L inclusive. (A) Shows normal haustra below and small patches of prediverticular state above. (B) Shows areas of prediverticular state involving circumference of bowel and causing apparent ring constriction. (C) The same piece of bowel as B after treatment. The constriction has disappeared. The irregularities present the aftermath of the prediverticular state. Some small pouches are in state of formation. (D) Small narrow necked diverticulum retaining fecal matter. (E) The same diverticulum four years later. (F) Widening of the re-entering angle at the neck of the diverticulum, the earliest roentgenological sign of inflammatory thickening of the bowel wall. (G) More advanced thickening. Note distance of lumen from peritoneal surface. (H) Isolation of diverticula from the lumen of the bowel. (I) The same bowel as H four years later showing advanced obliterative stage. (J) Swollen folds of mucous membrane shown by arrows; also acute prediverticular stage supervening on chronic diverticulitis. (K) Diverticulous bowel. (L) The same piece of bowel seven years later showing new disease supervening on the old area of diverticulosis.

the colon which they considered almost pathognomonic of chronic diverticulitis, even though the roentgenogram might not show diverticula themselves. They said:

"Particularly along the descending colon and sigmoid one occasionally finds a peculiar serrated appearance. This may extend over several inches of gut and is associated with more or less narrowing of the lumen. These serrations are

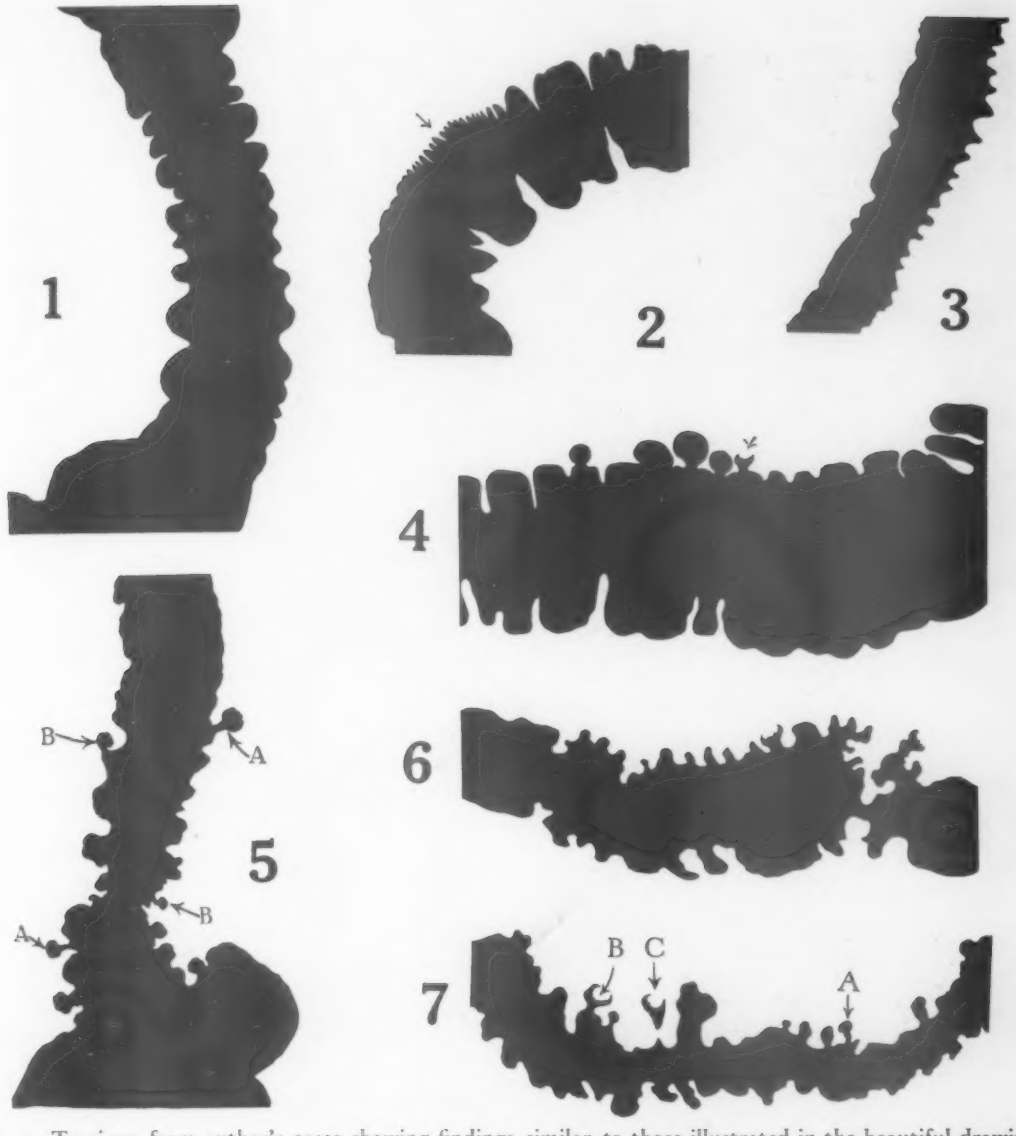

Fig. 5. Tracings from author's cases showing findings similar to those illustrated in the beautiful drawings by Spriggs and Marxer (Fig. 4). (1) Shows beginning diverticulosis with some irritation of the bowel. (2) The concertina appearance shown at arrow which is so characteristic of a prediverticular state. (3) A more advanced stage of 2. (4) Diverticulosis with retention of fecal material in one of the diverticula (shown at arrow). (5) Advanced diverticulitis. Note the width of the re-entering angle in the diverticula shown at A and to a lesser extent in the diverticula shown at B. The width of this re-entering angle indicates the degree of inflammatory thickening attending the diverticulum. (6) and (7) Other instances of advanced diverticulitis.

small, close together, and with a rather sharp point, presenting at times a sawtooth appearance . . . Repeated examinations given on different days show this appearance to be constant . . . The serrations do not change in size or shape. Furthermore, palpation under the fluoroscopic screen usually shows us that the intestine is more or less like a rigid tube . . . One infers that the serrated appearance is due to inflammatory thickening and induration of and about the intestinal wall, secondary to the presence of diverticula, the diverticula themselves not being visible."

This sounds very similar to the "prediverticular" state described by Spriggs and Marxer[14] (Figs. 4 and 5). According to the latter, the normal segmentation of the bowel is absent, being replaced by a ragged outline of little convex irregularities,

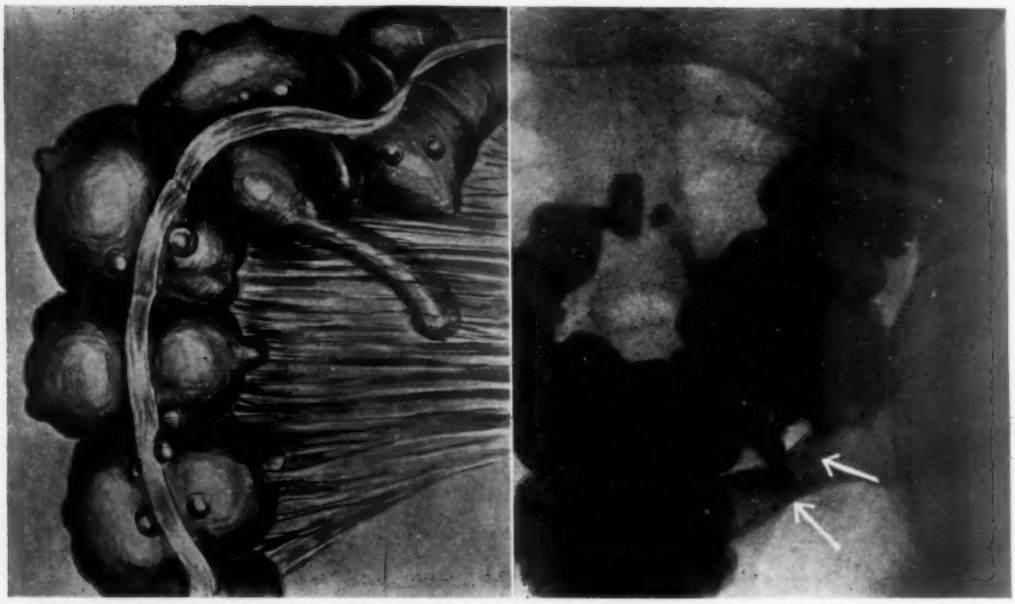

Fig. 6. Left—Illustration from Lockart-Mummery showing the typical positions and shapes of colonic diverticula. Some are antimesenteric. Some lie between the folds of the mesentery, occasionally forming long finger-like pouches, and some occupy the free border of the colon, usually near the exits of blood vessels. Right—Roentgenogram showing at arrows long finger-like diverticula similar to the one illustrated in the preceding drawing from Lockhart-Mummery. (Author's case.)

Fig. 7. A case of fibroid tumor of uterus shown on the left four hours after a barium meal, displacing the small intestine upward in a very characteristic manner. On the right, the fibroid tumor shows its pressure upon the enema filled colon.

often seen along one side of the bowel only and sometimes confined to one haustrum only. In nearly all cases it is possible to detect at the same time both the prediverticular state and small diverticula in one part or another of the colon. A new fact brought out by Spriggs and Marxer is that this stage precedes the formation of the pouches and apparently is associated with some weakening of the submucosa and of the muscular layers. It is while the prediverticular state is in evidence that

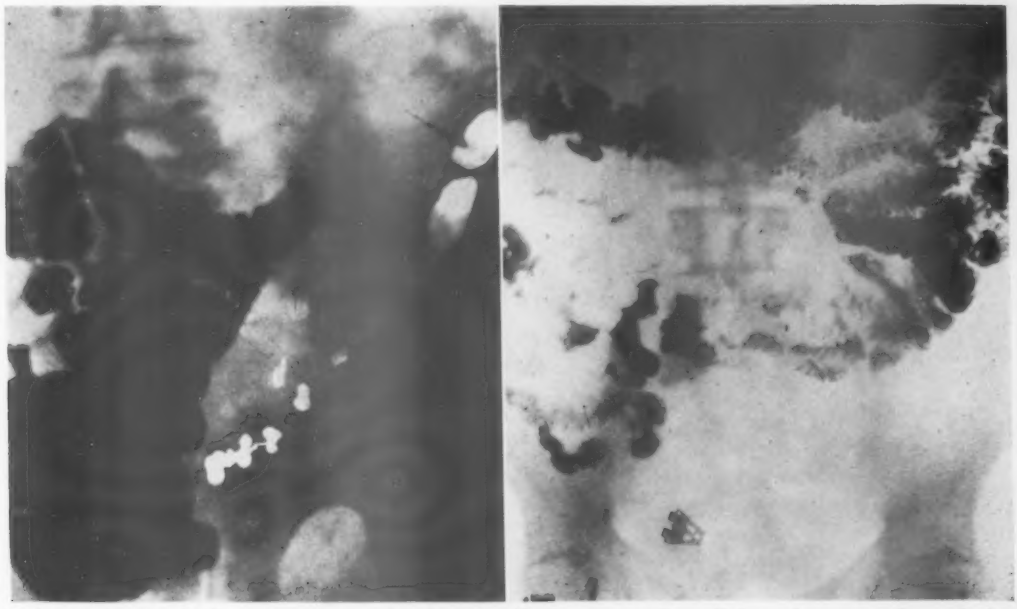

Fig. 8. Left—A retouched roentgenogram showing the displacement of small intestine away from the inguinal region to a much greater extent than usual. Note the distance between the lumen of the colon as revealed by its contained gas and the nearest loop of small intestine. It is obvious that this represents thickness of the wall of the colon and the superimposed inflamed or infiltrated epiploic appendage. In cases of advanced obesity this sign might have no value. Right—A similar case not retouched.

the minute hernias which subsequently form diverticula are pushed between the muscle fibers. Following this appearance of the prediverticular state there is often observed a stage of irritation causing a larger concertina-like appearance, sometimes giving to the colon shadow contours closely resembling the shadow of small intestine when slightly distended. This is followed by the fully developed diverticula of various sizes and shapes, many of them, even large ones, being made up of all the coats of the bowel as proven by the fact that they can be observed to contract.

The exact shape of the diverticular shadow obtained with the opaque meal or enema depends upon the diameter of the orifice of the diverticula. If the orifice is wide enough, the diverticulum does not retain its non-opaque contents and the opaque material has no difficulty in entering the whole of the diverticulum and filling it, giving a perfectly rounded or ovoid shadow. In a diverticulum with a narrow orifice, however, the opaque meal does not displace the former non-opaque content but fills only the proximal portion of the pouch lying next to the lumen of the bowel, thus giving rise to a very characteristic crescentic opaque shadow. Occasionally one sees long finger-like diverticula closely resembling the vermi-

Fig. 9. A roentgenogram similar to those shown in Figure 8 but with the diverticulous colon sketchedin.

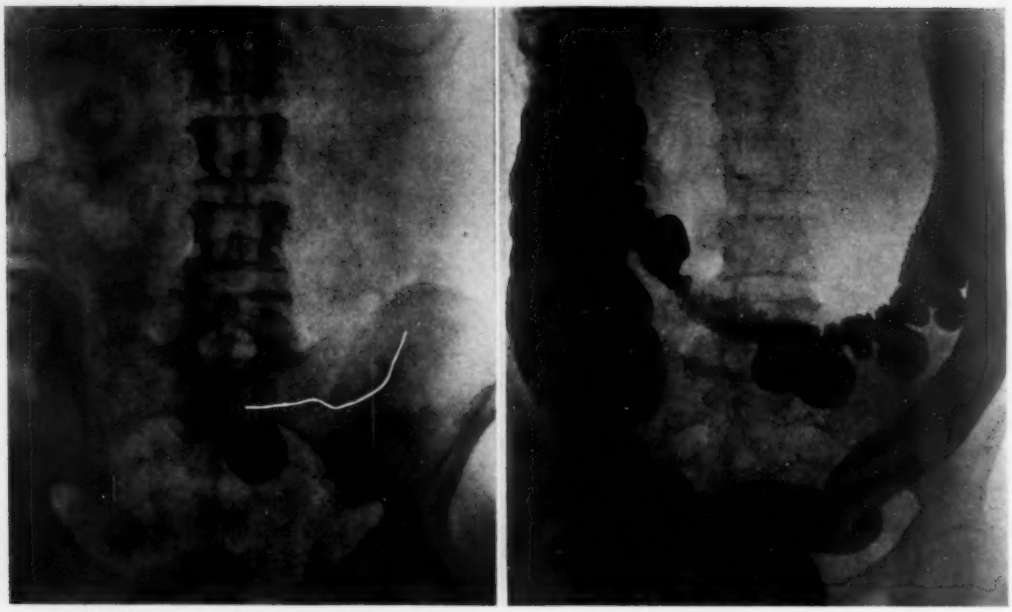

Fig. 10. On the left, several large diverticula of the transverse colon shown fifty hours following a barium meal and persisting in spite of cleansing enemas. On the right, the same diverticula shown in relation to the colon after the injection of the opaque enema.

Fig. 11. The diverticula of Figure 10 as seen at the operating table.

form appendix, sometimes shaped like an Indian club, extending between the folds of the mesocolon (Fig. 6). It is quite possible that in acute diverticulitis in certain areas, the orifices of the diverticula may be completely obstructed so that it is impossible to fill them by the enema or by the opaque meal, but elsewhere in the same colon it should always be possible to demonstrate the diverticula or diverticulitis.

Fig. 12. The diverticula of Figures 10 and 11 shown from the lumen of the bowel after surgical removal.

As the third important step in the development of the roentgen-ray study of diverticula, the writer offers still a new observation. At a certain stage in each opaque meal examination, toward the end of gastric clearance, one sees the small intestinal loops well visualized. Naturally the ileac coils occupy the true pelvis, the jejunal coils lying higher in the abdomen, and toward the left the terminal coil of ileum is noted reaching up out of the true pelvis toward the ileocecal junction on the right side. When there exist fibroids, ovarian cysts and other pelvic tumors, pathological and physiological, the small intestine is lifted out of the true pelvis higher up into the abdomen. We have

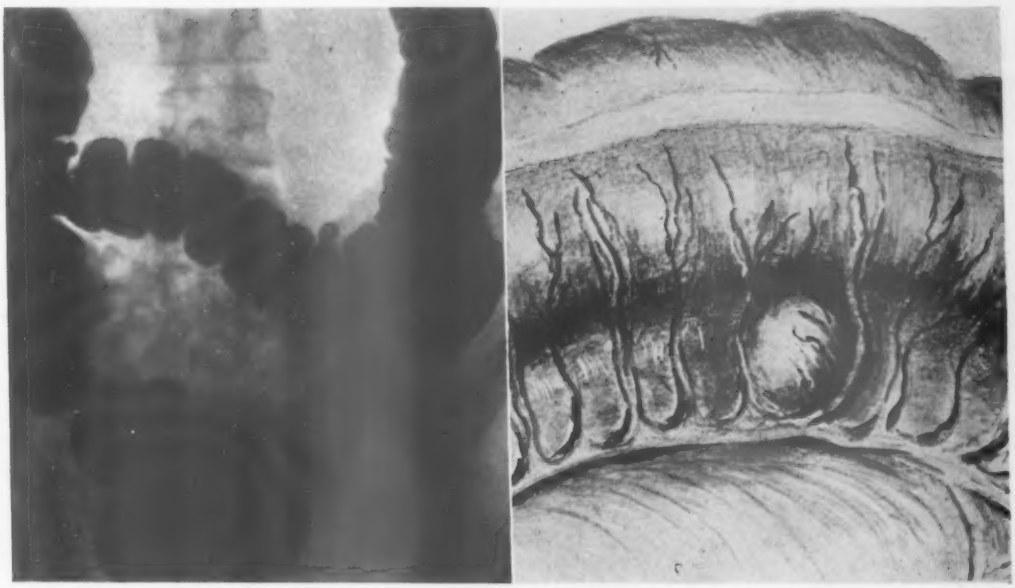

Fig. 13. Left—Two small diverticula of the transverse colon. Right—One of the diverticula as seen at the operating table.

observed for years a similar roentgen appearance in certain cases of diverticulitis of the sigmoid; several hours before this part of the colon has been visualized, one notes a displacement of the small intestinal coils upward and toward the right (Fig. 8). The normal undistended colon is easily compressible; when distended by gas, the gas is clearly observable, or, if filled by non-opaque fecal matter, this can be determined by a cleansing enema. But with these possibilities ruled out, the amount of displacement is such that one can suspect a fat-laden sigmoid covered with swollen and edematous or inflamed epiploic appendages, the total forming a mass of considerable proportions (Fig. 9). The idea that this finding (displacement of the small intestine upward and toward the right away from the left iliac fossa) may be due to the diverticula-laden sigmoid with marked peridiverticular manifestations, is strengthened in some cases by carefully noting the gas content of the area of sigmoid under suspicion, as in Figure 8. Here one sees clearly the gas content of the sigmoid, a row of small gas collections nowhere exceeding one-half inch in diameter (indicated by arrows), and yet the vacant space in the left iliac region due to the displacement of the small intestine is at least three inches in diameter. It is manifest that the difference between the three inches of vacant space and the half inch of colonic lumen represents the mass made up of the fat-laden, enlarged epiploic appendages attached to the already thickened walls of the colon.

For the meal we prefer barium sulphate in buttermilk or one of the prepared media which only requires the addition of warm water. For the opaque enema we employ barium sulphate in warm buttermilk or in a gum suspension.* Exquisite pains should be taken with the roentgenographic technique in order to obtain every possible bit of fine detail. An accurate study of diverticulitis cannot be made except with first class roentgenograms.

When one detects in the pelvic colon a filling defect with a localized narrowing of the lumen of the bowel, carcinoma rather than diverticulitis is naturally suggested, but it must be remembered that diverticulitis may coexist with carcinoma and

*Our old formula is as follows: To 2½ dr. of gum tragacanth, add 20 oz. of warm water and shake. This may be made up in larger quantities in stock solution and kept on ice. To the stated amount of 2½ dr. of gum and 20 oz. of warm water, add 3 oz. of barium sulphate, then 20 oz. of water, shaking well each time. This mixture should be made up fresh shortly before using.

Ordinary buttermilk or mineral oil (Paralax, Petrol-agar, etc.), warmed to the temperature of 100° F., serves very well as a vehicle for the suspension of the barium for enema purposes. This latter preparation has the advantage of being quickly made ready.

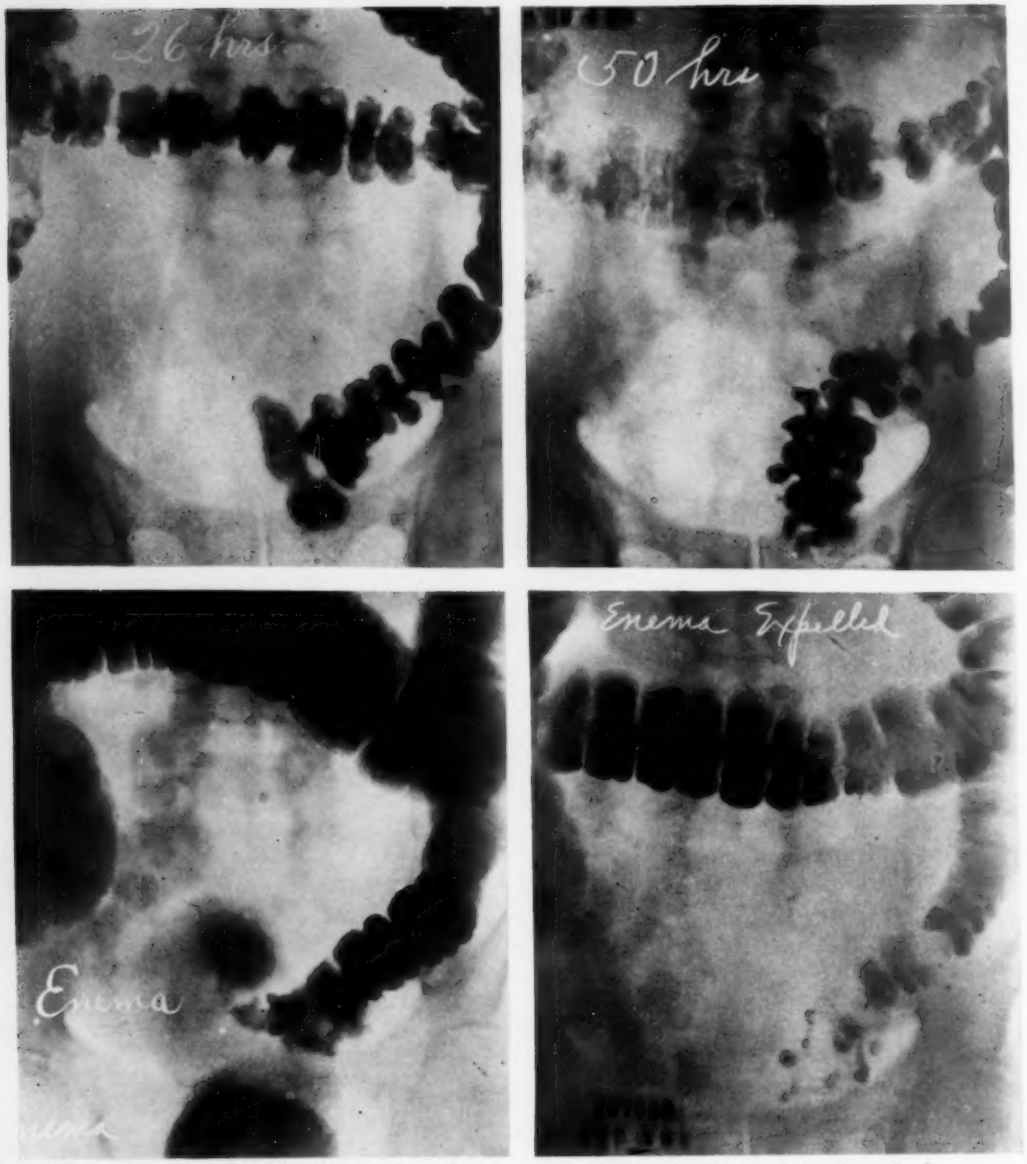

Fig. 14. Four steps of an examination of the colon in a case of diverticulitis to determine whether or not there is associated obstruction. Left Upper—The twenty-six hour roentgenogram showing barium in the colon as far as the diverticulous sigmoid. Right Upper—Same colon at fifty hours p.c. showing no further progress of the barium column. Diverticula more marked. Left Lower—The same colon filled by opaque enema. Note evidence of obstruction in pelvic colon. Right Lower—The same colon after attempt to expel the opaque enema. Note that expulsion occurs only below the point of obstruction.

that either condition may precede the other. At any rate, a coexistence of carcinoma with diverticulitis occurred in about 15 per cent of the Mayo Clinic cases. Ballin[2] believes that carcinoma arising in a diverticulum has certain characteristics in that it does not often grow toward or encroach upon the lumen of the bowel, and, therefore, a filling defect may not be apparent in the roentgenogram. Telling thinks it likely that carcinoma can cause diverticula, and he is certain that diverticula may be followed by carcinoma formation; this leads him to state the following very important axiom:

No case of supposed carcinoma of the lower bowel must in future be regarded as inoperable either before or at laparotomy

unless diverticulitis has been remembered, fully considered and systematically investigated.

The differential diagnosis involves especially sigmoiditis, hyperplastic tuberculosis, carcinoma, actinomycosis, syphilis, left-sided (true, transposed) appendicitis, and certain pelvic conditions. Sigmoiditis is an older disease which may have a special dysenteric or local bacterial origin. It is probable that most of the reported cases of sigmoiditis were cases of diverticulitis. Some cases of sigmoiditis occur at earlier ages; the greater portion of them end in spontaneous recovery. There is more frequently an involvement of the mucosa. Syphilis is rare in the sigmoid; anyhow there are other evidences of lues which can be brought out in any suspected case. Actinomycosis usually occurs in the cecum, and the clinical and pathological developments are very much different than in diverticulitis. Hyperplastic tuberculosis is rare in the sigmoid although it does occur. Mailer[10] reports two cases in which there was operatively proved a coexistence of diverticulitis and tuberculosis of the sigmoid. Pelvic lesions are usually left sided, but the bimanual examination and the history usually permit a differentiation. In making studies of gynecological cases it is well always to keep in mind a possible diverticular lesion. Differentiation must also be made between diverticulitis and fecal impaction, encysted foreign bodies, chronic abscess, fistula and vesical tumor. The most important and sometimes the most difficult differentiation involves carcinoma of the sigmoid. In carcinoma of the pelvic colon, loss of flesh occurs early, and the formation of a palpable tumor usually precedes the development of pain and tenderness.

SUMMARY

1. Diverticulosis of the colon is a symptomless condition commonly met with in alimentary tract roentgenology. As the name implies, there is no recognized inflammatory reaction to the diverticulosis.

2. Diverticulitis is a sequel of diverticulosis, also commonly encountered, the inflammatory sequels manifesting themselves in various ways so that cases may be clinically classified as of the enterospasm type, the hyperplastic type and the pseudo-appendicitis type.

3. A prediverticular stage has been described by George and Leonard and by Spriggs and Marxer and should be looked for and recognized when present.

4. A new sign of pericolic thickening is offered by the writer.

5. Colonic diverticulitis which so closely mimics carcinoma can be best differentiated from carcinoma by roentgen study.

6. No case of supposed carcinoma of the lower bowel should be regarded as inoperable either before or during laparotomy until the question of diverticulitis has been considered and if possible settled.

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DISCUSSION

Dr. L. T. LeWald, New York City. This is a very important subject. I think when we first observe diverticula we regard them with interest, but hardly appreciate the rôle that diverticulosis and diverticulitis really play in medical and surgical conditions of the gastro-intestinal tract.

Dr. Case and Dr. Upson have brought out some new points today. It is very difficult to distinguish diverticula at times, I mean inflamed diverticula, diverticulitis, from simple diverticulosis, and perhaps Dr. Upson will stress the points again on which he bases that distinction.

Dr. P. M. Hickey, Ann Arbor, Mich. I should like to ask Dr. Upson how much air he thinks necessary to inject for the elicitation of that sign, whether he distends the colon or just puts in a small amount of air.

Dr. Upson (closing). I am glad to have the discussion, especially from Dr. LeWald. He will find his queries fully answered in the text of Dr. Case's paper.

Dr. Hickey asked how much air we put in. That depends on how much the patient will conveniently stand. This should be done under a fluoroscopic screen, and when you are able to demonstrate the lumen of that portion of the bowel with air then stop and take the roentgenogram with the patient still on the fluoroscopic table. If you do not want to use air, use just a small amount of thick barium, a rather thick mixture, putting enough in to demonstrate the lumen of that portion of the bowel.

THE ROENTGENOLOGICAL FINDINGS IN MITRAL STENOSIS AND INSUFFICIENCY*

BY DAVID STEEL, M.D.

CLEVELAND, OHIO

THIS paper includes a review of the more important contributions on this subject and a statement of the findings in about 100 cases carefully observed roentgenologically, clinically and pathologically. The roentgenological data were obtained from a roentgenoscopic examination and seven foot plates taken in the anteroposterior and both oblique positions. The site of the various chambers was determined at autopsy in both the normal and abnormal. Standard works, especially those of Assmann and Groedel, were used as guides.

Without a thorough knowledge of the position of the various chambers in the normal, one can scarcely hope to draw intelligent conclusions in the abnormal. Figures 1, 2 and 3 show these positions in the normal. The normal position of the left atrium and the right ventricle should particularly be noticed. In the first oblique position a rotation of about 45° brings the right atrium into Holzknecht's space. With further rotation the right atrium is replaced by the left atrium. At 90° the latter is entirely in the border. This position is an important one for the study of the enlarged left atrium. Some prefer the second oblique or its inverse. Personally I prefer the first oblique.

In the presence of a mitral lesion the left atrium readily undergoes hypertrophy and dilatation. Enlargement of this chamber has been a constant finding in all the cases observed. The left atrium with its venous tributaries will accommodate a large volume of blood. There is, in addition, an increased amount of blood in the lesser circulation. Because of this latter increase, some maintain that there is an increased pressure in the lesser circulation. This "back pressure" theory is used to explain the right-sided hypertrophy.

* From the Roentgenological Departments of the Cleveland City Hospital and Western Reserve Medical School, Cleveland, Ohio. Read at the Twenty-ninth Annual Meeting, American Roentgen Ray Society, Kansas City, Mo., Sept. 25–28, 1928.

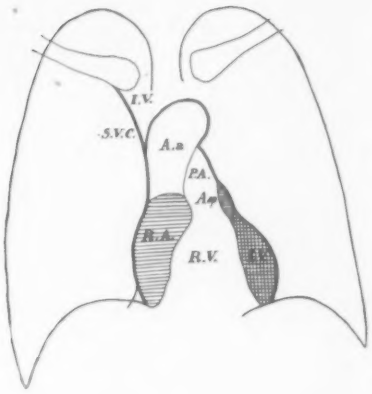

Fig. 1. Diagram of the normal heart in the anteroposterior position.

S.V.C. = Superior vena cava.
I.V. = Innominate vein.
A.a. = Ascending aorta.
P.A. = Pulmonary artery.
A.ap. = Left auricular appendage.
R.V. = Right ventricle.
R.A. = Right atrium.
L.V. = Left ventricle.

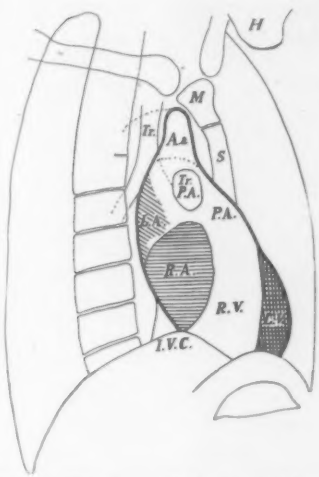

Fig. 2. Diagram of the normal heart in the first oblique position.

I.V.C. = Inferior vena cava.
L.A. = Left atrium.
Tr. = Trachea.
A.a. = Ascending aorta.
Tr.P.A. = Cross section of the pulmonary artery.
P.A. = Pulmonary artery.
R.V. = Right ventricle.
L.V. = Left ventricle.
M = Manubrium.
S = Sternum.
H = Head of humerus.

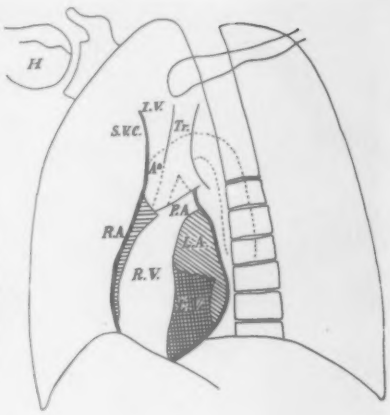

Fig. 3. Diagram of the normal heart in an exaggerated second oblique position.

R.A. = Right atrium.
S.V.C. = Superior vena cava.
I.V. = Innominate vein.
A.a. = Ascending aorta.
P.A. = Pulmonary artery.
L.V. = Left ventricle.
Tr. = Trachea.
H = Humerus.
R.V. = Right ventricle.

Fig. 4. Pure mitral stenosis.

Fig. 5. Mitral stenosis in the first oblique position. The midportion of the retrocardiac space is obliterated.

Fig. 6. Mitral stenosis in the first oblique position. The mid- and lower portions of the retrocardiac space are obliterated. The lesion is more advanced than in the previous figure.

kenzie attributed the right heart hypertrophy to myocardial weakness. No one theory seems adequate. A large percentage of these cases are associated with a well-marked pulmonary arteriosclerosis. This might play a part in the hypertrophy or it might be secondary to it. We must admit, however, that there are always changes in the right heart and it is to these changes that the main findings in the silhouette are ascribed.

To the right ventricle is attributed an important rôle in the production of the mitral configuration. As seen from the diagrams, the right ventricle is entirely anterior, resting inferiorly on the diaphragm and impinging anteriorly against the chest wall. Because of these two barriers an enlargement of the right ventricle will cause a rotation of the heart, which rotation, when viewed from the apex, takes place in a clock-wise direction. As a result the left ventricle goes posteriorly; the pulmonary artery is rotated to the left and becomes more prominent;

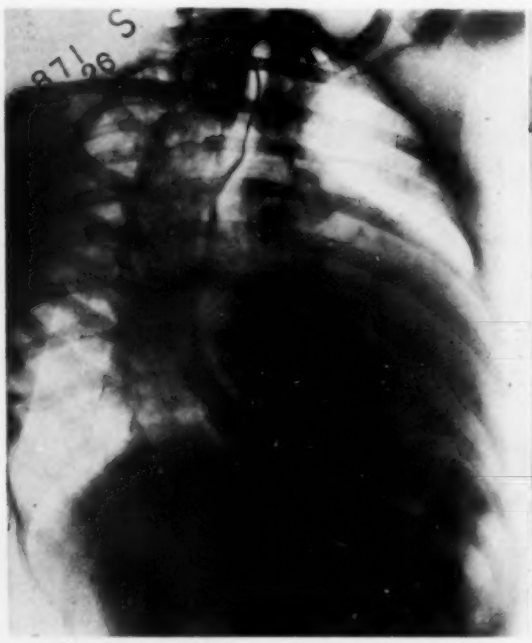

Fig. 7. The barium-filled esophagus is displaced posteriorly and to the right by the enlarged left atrium.

Fig. 8. Mitral stenosis in the second oblique position.

According to MacCallum and McClure there is an increase in pressure within the pulmonary artery and left atrium. Mac-

the left atrium is rotated further posteriorly; and that portion which is normally posterior, goes more posterior and to the right; the aortic knob is rotated posteriorly;

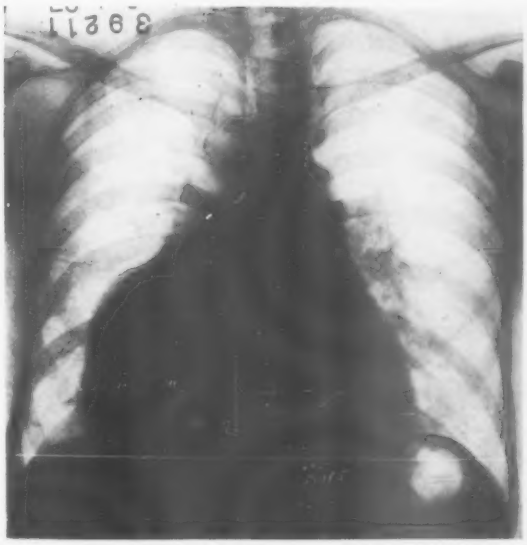

Fig. 9. The enlarged left atrium extends beyond the shadow of the right atrium and forms a portion of the right cardiac silhouette.

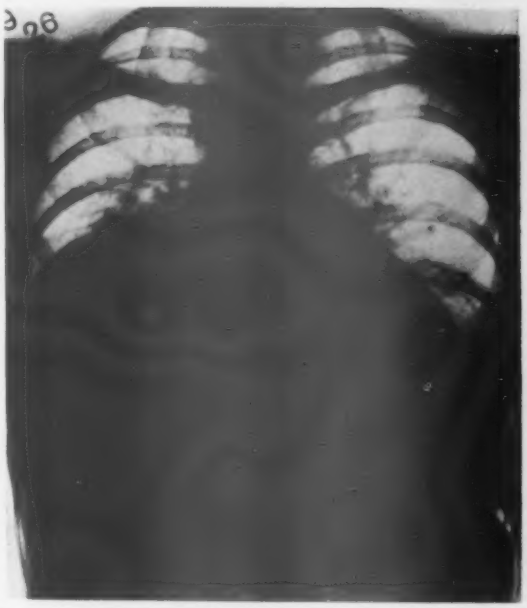

Fig. 11. The enlarged left atrium forms the entire right cardiac silhouette.

Fig. 10. The enlarged left atrium can be seen as a denser shadow through the lighter shadow of the right atrium (arrow).

Fig. 12. Mitral insufficiency in the anteroposterior position. Note the increased measurement of the right hilus.

the right atrium is elevated and displaced anteriorly, due partly to the flattening effect of the right ventricle. The heart as a whole assumes the oblique, upright or "standing egg" position, its angle of inclination to the horizontal being increased.

In the anteroposterior view (Fig. 4) the following changes are to be noted in a case of mitral stenosis:

(1) The heart is in the erect position and it appears long and narrow.

(2) The left border is straight. The incisura is filled out by the pulmonary artery and left auricular appendage. The left median distance in a case of uncomplicated mitral stenosis is

Fig. 13. Mitral insufficiency in the second oblique position. The silhouette is rounded.

small. "The straighter and steeper the left silhouette, the more is the left border formed by the right ventricle, and vice versa" (Assmann).

(3) The aortic knob is insignificant or entirely hidden in the shadow of the spine. This is due in part to the habitual scanty filling of the aorta and in part to rotation.

(4) The second arch (pulmonary artery) joins the aortic knob high up.

(5) The pulmonary artery is increased in prominence due to the rotation and to an actual increase in its diameter.

(6) The right auricular curve is long and joins the ascending aorta higher than normally.

(7) The hilus regions are increased (Figs. 4 and 12). Due to anatomical relations the main descending branch of the right pulmonary artery is distinctly visible in about one-third of the cases and it is possible to measure its width. The cases selected for measurement must be free from glandular disease of the hilus and from pulmonary disease and should show a sharply defined artery. Assmann states that normally this measurement varies between 11 and 14 mm., with an average of 13 mm. He considers a measurement above 15 mm. to be pathological.

In the first oblique position (Fig. 5) the change is quite characteristic. Here also the erect position of the heart is maintained. The pulmonary artery is prominent and this is the position par excellence for its demonstration. The main finding in this position is due to the enlarged left atrium. As stated above, this chamber is rotated farther posteriorly. Normally the retrocardiac space can be easily made out, especially in deep inspiration, as a clear band in front of the spine shadow. In moderate cases of mitral disease the mid-portion is partially obliterated by the left atrium, leaving a normal radiant lower portion which is characteristically triangular in outline. In advanced cases (Fig. 6) the mid- and lower portions are entirely obliterated. This posterior encroachment can also be demonstrated by examination of the barium-filled esophagus. It is easy to demonstrate a posterior and right displacement of the latter, which will be seen to be riding over the enlarged atrium (Fig. 7).

We can therefore add:

(8) The enlarged left atrium encroaches upon the midportion of the retrocardiac space, and in well-marked cases, obliterates it, leaving characteristically a clear triangular area of normal radiability in the lower portion.

(9) The displaced esophagus can be demonstrated after ingestion of barium. It will be found to be displaced to the right and riding over the enlarged left atrium.

The second oblique position (Fig. 8) will demonstrate the right-sided enlargement when no evidence of enlargement can be detected in the anteroposterior view. The right lower arch will be seen to be more arched than normally and definitely elongated. This position is preferred by some for the early detection of an enlarged left atrium. The inverse second oblique is also recommended. I prefer the first oblique at a rotation of about 70°.

There is some difference of opinion as to the rôle the left atrium plays in the formation of the left cardiac silhouette. I have not seen a single case at autopsy where the left atrium could possibly have formed a portion of the left border. In every case the third arch could be ascribed only to the left auricular appendage. Even in cases of marked auricular enlargement the appendage only has been in the border. The left atrium is normally posterior. With rotation of the heart, it is even more posterior and is displaced to the right.

When enlarged moderately, it will form an arch above the right auricular curve (Fig. 9). Sometimes there is a demonstrable niche to show the junction of these two chambers. At other times the outline of the left atrium can be seen through the shadow of the right atrium (Fig. 10). In advanced left auricular dilatation the latter chamber can form the entire right cardiac border. Figure 11 is a teleroentgenogram of a female, aged thirty-one, who had several admissions to the hospital from October, 1925, to August, 1926. She had had two attacks of rheumatic fever, one at the age of sixteen, and one at twenty-seven. After the first attack, she had dyspnea on exertion and for the past twelve years has had precordial pain, palpitation and has been a cardiac invalid. Roentgenoscopically there was seen a rounded mass protruding into the retrocardiac space, which was entirely obliterated in the lower two-thirds. As the patient was rotated into the first oblique position, this mass was seen to appear to the patient's right from behind the right cardiac border. It showed only very slight pulsation of a wavy character and could not be separated from the heart shadow. It was diagnosed as the left atrium.

At post mortem the left atrium formed the entire right cardiac border. Only the appendage was visible on the left. A probe inserted into the appendage passed posteriorly and to the right, and all but touched the right axillary border. The left atrium, which held 700 c.c. of salt solution, apparently found its way between the hilus region and the right atrium. The anatomical diagnoses were (1) acute, superimposed on a chronic valvulitis of the aortic, mitral and tricuspid valves; (2) cardiac hypertrophy and dilatation, especially left atrium and right ventricle, and (3) chronic circumscribed adhesive pericarditis.

The signs of mitral insufficiency (Fig. 12) are a little more complicated. The steep, oblique position, which we recognize as mitral configuration, is maintained in insufficiency. This position is due to the right ventricle.

The chambers on the left are usually more or less fused into one another. The pulmonary artery and auricular appendage are not so well defined as in stenosis. The left ventricle is increased so that there is present an increase of the left median distance. In stenosis the cardiac incisura is filled out. In mild cases of insufficiency the incisura is partially restored by the hypertrophic and dilated left ventricle. In advanced cases the incisura might be replaced by an outward convex shadow due to the markedly dilated pulmonary artery. The silhouette is no longer narrow because of the large left ventricle. When insufficiency of the right ventricle takes place the right atrium enlarges. There is then an enlargement of all the chambers. The right median distance now becomes increased and the silhouette is bag-shaped in the anteroposterior view. In the second oblique the silhouette is rounded (Fig. 13).

Many times when the clinical examination indicates one or the other lesion, the roentgen examination suggests the presence of both. In such cases, the silhouette depends on which lesion predominates. An unusually marked third left arch speaks for a stenosis. An enlarged left ventricle indicates an insufficiency.

Care must be taken not to mistake a pure right heart hypertrophy for a mitral lesion. The so-called mitral configuration can be approached when the right ventricle becomes hypertrophic from any cause, most commonly from those diseases which cause an increase in the pressure of the lesser circulation. Under such conditions the heart might undergo a rotation, but the left atrium will not be enlarged and the pulmonary artery will not be as prominent.

Greater difficulty in diagnosis is experienced in those cases where there is superimposed on a left ventricular enlargement, a hypertrophy of the right. Here the demonstration of a normal left atrium is particularly important.

CONCLUSIONS

The roentgenological findings of mitral stenosis and insufficiency are characteristic and a diagnosis of these lesions can often be made when the clinical findings are not conclusive. I wish to call particular attention to the position the left atrium takes when it becomes enlarged. It does not go

to the left, but, on the contrary, finds its way between the right hilus and the right atrium and in extreme cases can form the entire border of the silhouette.

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THE RÔLE OF THE ROENTGEN RAY IN DETERMINING THE RESECTABILITY OF GASTRIC CANCER*

BY ALEXANDER B. MOORE, M.D.

Section on Roentgenology, The Mayo Clinic

ROCHESTER, MINNESOTA

So long as radical surgical removal remains the treatment of choice for cancer of the stomach, the numerous clinical and roentgenologic factors which determine operability will need to be considered in every instance. The clinician takes account of the patient's general condition, the degree and nature of his anemia, and searches for signs of metastasis. Many other conditions enter into the clinical aspect of the problem, and in addition to these the surgeon applies criteria learned from experience. Underlying all factors affecting resectability are three of basic importance, namely, the situation of the gastric cancer, the presence or absence of fixation to adjacent structures, and the presence or absence of metastasis. Roentgenologic examination yields fairly definite information regarding the first named factor, is of great service in determining the second, and occasionally throws light on the third. At all events, notwithstanding its limitations, the roentgen ray has become virtually indispensable in sparing a considerable proportion of patients from futile surgical exploration.

By demonstrating the seat and extent of the new growth the roentgen ray renders its greatest service. Cancers in the cardiac third of the stomach are sheltered by the costal arch and are rarely accessible to resection, while those in the pyloric third are readily resectable so far as situation

* Read at the Twenty-ninth Annual Meeting, American Roentgen Ray Society, Kansas City, Mo., Sept. 25–28, 1928.

alone is concerned. In general, cancers confined to the lower half of the stomach can be excised, but are not resectable if they affect the upper half. On the lesser curvature the incisura angularis marks a point above which the extension of a cancer renders the chance of its resection uncertain. In persons of the broad habitus the wide costal arch facilitates surgical maneuvers, and a cancer which has extended two or three centimeters above the incisure may be resectable, whereas, in a slender patient with a narrow arch excision might not be feasible. It is often difficult to determine the limits of the carcinomatous invasion. Soft, fungoid cancer tends to produce a grossly irregular filling defect which represents closely the actual extent of the growth, but the defect of an infiltrating scirrhous cancer merges into an apparently normal gastric contour, and the extent of the growth exceeds that depicted. To cover error in such instances an allowance of two or three centimeters should be made. Notwithstanding all care, estimates of the extent of disease will often fall short.

The cancerous stomach often becomes adherent to the pancreas, mesocolon, liver, omentum, colon, or abdominal wall, either as a result of extra-gastric extension of the cancer or simple inflammatory reaction. Obviously the adherent area varies in extent, with a proportionate degree of fixation. Quite frequently a line of cleavage can be established surgically, and the growth freed with ease. However, if the attachment is deep and firm, or if the neighboring structures have been extensively invaded by the process, resection is likely to be impossible. Although gastric cancer very rarely invades the duodenum, the latter may become immobilized by inflammatory adhesions, thereby making resection more difficult, as Balfour has pointed out. Fungoid cancers are more likely to become adherent than those of the scirrhous variety. Deeply ulcerating cancers on the posterior wall are less often adherent than those on the lesser curvature. Cancer limited to the lesser curvature is attached more often than cancer of the posterior or anterior wall. Cancer of the greater curvature tends to implicate the transverse colon. Fixation is to be surmised when a cancer is extensive, or when the palpable tumor greatly exceeds the visible defect in the gastric shadow.

Since the barium in the stomach, especially in its unaffected portion, can be displaced by manipulation, the stomach itself may appear to be mobile although really adherent. To avoid this error, attention should be directed to the palpable mass and the result of efforts to displace it. Attachment to the pancreas, which may itself be mobile, is hard to discover. Extension of a cancer of the greater curvature to the transverse colon is best confirmed or excluded by examination with the barium enema.

Concerning metastasis the roentgen ray yields scant information. Metastasis to the lungs or bones is demonstrable roentgenographically, but occurs so rarely from gastric cancer that it scarcely enters into consideration. Metastasis to the abdominal lymphatics and the liver is common. Neither is visible with the roentgen ray. Occasionally metastatic nodular masses can be felt separate from the gastric tumor by the examiner, whose palpation is favored by the posture of the patient and the orientation permitted by roentgenoscopy. As a rule, however, evidence of metastasis will not be revealed and it remains the most common of all obstacles to radical and effective operation.

Polypoid cancers, single or multiple, primarily or secondarily malignant, often produce central filling defects without deformity of the curvatures. They resemble benign tumors except that they are usually palpable, and it has been my experience that any polypoid gastric neoplasm which is palpable is malignant. These tumors are rarely adherent, seldom give rise to metastasis and can usually be removed by a skilled surgeon irrespective of their situation.

Malignant ulcers, as distinguished from ulcerating cancers with definite tumefaction, are of two types. One type is relatively small, sometimes quite minute, has all the roentgenologic marks of simple ulcer and its malign nature is disclosed only with the microscope. The other is so large that its malignant character is likely

to be suspected. Either variety may be inoperable by reason of high situation or metastasis but rather seldom because of extra-gastric invasion or attachment. Ulcers which perforate the gastric wall, burrow deeply into adjacent tissues and produce an accessory pocket, are usually benign.

For many years the foregoing indexes of operability have been applied at The Mayo Clinic, and in order to appraise the results the cases of 400 consecutive patients examined and operated on or explored during the last two years have been reviewed. In 196 cases the growth was radically excised, while in 204 removal was impracticable or impossible, although in 32 of the latter group gastroenterostomy was performed to relieve obstruction.

Among the 196 cases in which resection was carried out, the roentgenologist had reported 179 as operable, 13 as of doubtful operability, and 4 as inoperable. It is noteworthy that in the 4 cases regarded by the examiner as inoperable, complete or almost complete gastrectomy was required, and the early mortality was extremely high. In 36 cases the surgeon found the stomach adherent to other structures, although in 23 the extent of attachment was slight; attachment to the pancreas and mesocolon predominated. The growth was of a polypoid character in 5 cases and in one of these apparently had been benign originally. In 26 cases the lesion was of the ulcer type, and only 5 exhibited roentgenologic indications of malignancy. Neither fixation nor metastasis was encountered in any of the 26 malignant ulcers.

Of the 204 cases explored and found non-resectable, 118 had been considered operable so far as could be determined with the roentgen ray, 51 as doubtful and 35 as inoperable. Non-resectability was accounted for solely by metastasis in 56 cases, by fixation alone in 49, by high invasion only in 28, and by various combinations of these elements in the remainder. Thus metastasis was a preventing factor in a total of 95 cases, fixation in 103, and high extension of the growth in 74. Metastasis to the liver was mentioned in 43 cases, to unspecified lymph nodes in 23, to the omentum in 13, and to the peritoneum in 7. When attachment occurred, the pancreas and mesocolon were most often implicated. In none of the inoperable cases was the tumor of a polypoid character. In 7 cases the lesion was essentially an ulcer rather than a tumor but was inoperable in 6 cases because of metastasis and in the remaining instance firm attachments prevented resection.

As compared with the leading part which the roentgen ray plays in the diagnosis of gastric cancer, its rôle in determining the operability of a given case is not brilliant. That its judgments are inaccurate is shown by the fact that in more than half the inoperable cases of this series hindrance to operation was not revealed by the roentgen ray. However, this is by no means the whole story. During the period covered by the series, several hundred other patients were spared a fruitless exploration because of information given by the roentgen ray, so that its actual value does not appear in these statistics. Further, it is worthy of repetition that among 196 cases in which the growth was resectable, the roentgen ray sanctioned operation in 179 (91 per cent). Again, the entire series of 400 cases included but 39 (10 per cent) in which operation was undertaken despite a roentgenologic report of "inoperable." Evidently, then, the interdict of the roentgen ray against an attempt at operation deserves and receives respect, while its assent to operation is merely conditional and subject to unavoidable error.

DISCUSSION

Dr. Ross Golden, New York City. I am glad Dr. Moore emphasized the difference between the large mass producing type of tumor and the infiltrating type. In the absence of the invasion of the lumen which we can demonstrate the gastric wall may be more extensively infiltrated than one would suspect.

Extensive growths sometimes show no metastasis and the surgeon is agreeably surprised when he opens the abdomen to find that a growth which at first glance appeared very extensive may be susceptible to resection.

In doubtful cases, I believe a patient deserves an exploration. Personally, if I were in that position I should want an exploration. I have just seen that type of case in which the resec-

tion gave the patient months, or even more than a year of comfortable life, and I have seen at least one case in which the follow-up was more than five years.

I disagree with Dr. Moore on only one small point, and that is concerning malignant ulcers. I think this is not the first time that disagreement on that point has arisen, but for some reason or other we do not see malignant ulcers. I think at the Presbyterian Hospital in New York more treatment for gastric ulcers is given on the medical than on the surgical side. Uncommonly surgery is the treatment of choice in gastric ulcer. The patient is always given an opportunity to improve under medical treatment. When the ulcers are removed, the pathologists do not find carcinoma. I think we must leave that discussion to the pathologist, but I do not know how to interpret a malignant ulcer. We see the small type which Dr. Moore mentioned.

Dr. Moore (closing). The question of malignant ulcer which Dr. Golden brings up is, to my mind, a very interesting one. I do not believe it is in the province of the roentgenologist, clinician, surgeon or pathologist to state anything about malignant changes in ulcers. I think such a change unquestionably happens, but I do not believe anyone knows how often it happens.

The crux of the situation, as I see it, lies in these small ulcers. So far as I am concerned, we are unable to say in a given instance whether or not we are dealing with an inflammatory simple ulcer or whether we are dealing with a small carcinoma. That is based solely on my own experience and, to my mind, is typified by one case very clearly. This man, a large, heavy set individual, came in for gastrointestinal examination and was reported as having normal stomach and duodenum. He was returned by the clinician with a note that this man had a perfect duodenal ulcer history. On re-examination I was able to find a normal duodenum, but on the lesser curvature of the stomach just above the angle there was a small niche which, conservatively, was not as large as a pencil point. He was operated on, his entire abdomen was studied and in that small niche which I saw there was a small carcinoma. I think we might say not an ulcer but a small carcinoma. It had all the roentgenologic aspects of ulcer and not of cancer. His history was typical of a peptic ulcer. Possibly, as Dr. Golden says, more medical treatment should be given in gastric ulcers. I think a high percentage of our cases have gone through nine separate and distinct medical cures before we see them.

A COMPARISON OF THE EFFICIENCY OF VALVE TUBE AND MECHANICALLY RECTIFIED ROENTGENOGRAPHIC MACHINES*

BY FRANCIS W. BISHOP AND STAFFORD L. WARREN, M.D.

ROCHESTER, NEW YORK

INTRODUCTION

WITHIN the past two or three years there has been considerable discussion regarding the merits of the thermionic valve tube rectified machine as compared with the mechanically rectified apparatus. In view of the paucity of information in the literature and the radical differences in design of machines made abroad and in the United States, it seemed timely to investigate as thoroughly as possible the properties and output of these two different types of roentgenographic machines. The great lack of information concerning the roentgenographic properties and the voltage and exposure relationships between these two machines has further stimulated us to make this study.

Most of the investigations reported in the literature have been concerned with the study of therapy machines of different types. Voltz[11] (1917), Rieber[9] (1922) and Chamberlain and Newell[2] (1924) among many others, have emphasized the changes in output corresponding to changes in the rectified current and voltage wave forms, although two machines may be operated at the same milliamperage and crest voltage.

Coolidge[3] (1922) in testing several differ-

* From the Department of Radiology of the University of Rochester, School of Medicine and Dentistry, and the Strong Memorial Hospital, Rochester, N. Y.

ent types of rectifiers and transformers for voltage and radiation output, from 140 to 298 kv., found very good agreement in the efficiency of these machines, though a constant potential machine had a very much greater output at the higher voltages.

Chamberlain and Newell[2] (1924) investigating the output of twenty-four different therapy machines found as much as 200 per cent variation among machines in use by various radiologists. Using a synchronized rotating shutter and a large ionization chamber, they attempted to plot out the change in the radiation output corresponding to variations in the rectified current reaching the tube. By this method they demonstrated the difference in the wave form of this current in a valve tube and a mechanically rectified (rotating disc) type of therapy machine. They attributed the tremendous variations in the machines which they measured to differences in wave form, although this subject per se was not discussed.

Dalton[4] (1927) carried on a number of experiments with Continental apparatus to determine the relative output of these two types of machines. He compared films and pastilles and concluded that the output of the two types of apparatus was practically equal at like settings of the machines. His method of comparison was not very conclusive because of the known fallibility of pastilles and the lack of control of the exposure of his films, the checking of voltage, etc.

Nasledow and Kacura[8] (1928) reviewed the work of others on the Continent and reported tests on four different makes of deep therapy machines, three of which employed two or more kenetrons or valve tubes, with and without condensers, and the fourth a transformer designed to operate at 100 cycles. They measured the depth doses with a Siemen's dosimeter and the crest voltage with a sphere gap. The intensities of the various wave lengths in the spectra from three of the machines were charted with the microphotometer of Koch. Their curves showed uniform differences among the machines, which were operated at various settings from 90 to 150 kv., with and without filtration. One machine was definitely less efficient and one 1.5 times more efficient than the two other machines. These results differ from those reported by Friedrich and Körner (1920) whose method they followed. Friedrich found practically no differences among three machines of different makes which he tested. Heyde and Saupe[5] (1926) found considerable variation in the wave form with resistance control in contrast to autotransformer control. Their curves show the expected deformation of the voltage and amperage oscillograph wave forms upon the insertion of resistance in the primary circuit of the transformer.

It should be emphasized that therapeutic and roentgenographic requirements are very different. Our studies have been concerned entirely with the end-result at roentgenographic settings. Direct visual comparison of films is not entirely satisfactory so that we have attempted to study density by photometric measurements as well as to make the usual physical studies available to us in this laboratory.

METHOD

For our tests two stock machines were obtained directly from their manufacturers. One employed a single valve tube, without condensers, operating as a half wave rectifier; the other a rotating rectifying mechanism of the so-called toroid type, with adjustable spherical collecting shoes, operating as a full wave rectifier. The capacity rating of the mechanically rectified machine was somewhat greater. This factor should be considered in comparative tests, from the viewpoint of efficiency at heavy loads, since at some settings one machine may be overloaded while the other is operating at its normal rating. We feel that we have eliminated this factor, as will be shown later.

A special power line with particularly good voltage regulation was used during the tests. The roentgenographic transformers, with the rectifying devices mounted upon them, were placed side by side on the floor (Fig. 1). A simple change-over switch was mounted between them to throw the high tension output of either machine into the high tension system and broad focus universal tube used during

the experiments. A calibrated sphere gap with an automatic indicating device was connected across the high tension system with a total series resistance of approximately 2 megohms. This could be operated behind the lead shield by a pull cord

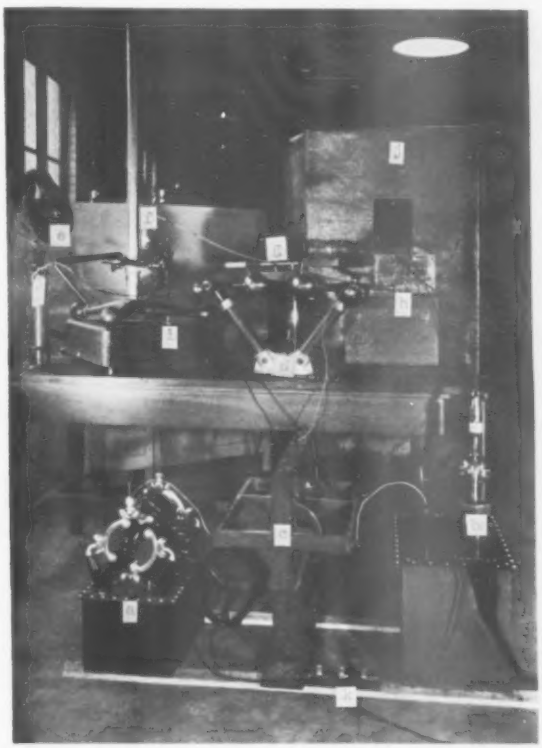

Fig. 1. Showing the two transformers with the mechanical (a) and valve tube (b) rectifiers; the change-over switch (c); the sphere gap (d); the high tension milliammeter (e); the tube (f); the spectrograph (g); the electroscope (h); the spinning top (i); the control booth (j); ground switch (k).

(Figs. 1 and 2). Three D.C. milliammeters were employed to check the measurement of the current in the high tension circuit. An additional milliammeter, capable of measuring high frequency currents, was inserted in the roentgen-ray tube circuit when necessary, to show the possible presence of high frequency currents. This meter was checked with the other meters on direct current.

The two control stands were placed behind a large movable lead shield (Fig. 2) and so connected that either machine could be used at will by throwing on the timer and circuit breaker circuit by means of a double throw switch. A microtimer of the synchronous motor and clutch type was used for all of the roentgenographic exposures. The timer was checked by the electroscope, and the spinning top and film methods, and found to be constant, giving the correct number of impulses for

Fig. 2. Showing the arrangement of the lead control booth; (a) microtimer and circuit breaker with push button; (b) line switch throwing timer circuit into either machine; (c) electroscope reset push button; (d) sphere gap pull cord; (e) valve tube machine control stand; (f) mechanically rectified machine control stand; (g) aluminum steps on binder; (h) tube in lead glass bowl; (i) high tension milliammeter; (j) blower.

each interval of time, throughout the course of the investigation.

A Seeman spectrograph (Fig. 1) was installed at a convenient distance from the target. This enabled us to calculate the crest voltages applied to the roentgen-ray tube, check the sphere gap readings, and study the composition of the roentgen beam from the two machines.

A calibrated electroscope (Fig. 1) was set in a fixed position near the spectrograph and facing the target of the roentgen tube. Electroscopic measurements were taken continuously during the exposure of the

TABLE I

MECHANICALLY RECTIFIED MACHINE					VALVE TUBE MACHINE				
I	II	III	IV	V	I	II	III	IV	V
Kilovolts Calculated from Minimum Wave Length in Spectrum	Sphere Gap Kv.	Ma.	Ionization, no Filter. Discharge Time of Electroscope	Ionization, 1 Mm. Aluminum Filter	Kilovolts Calculated from Minimum Wave Length in Spectrum	Sphere Gap Kv.	Ma.	Ionization, no Filter. Discharge Time of Electroscope	Ionization, 1 Mm. Aluminum Filter
	81	8	14.5	25.2		79	8	13.8	27.2
		8	13.8				8	13.8	
		8	13.8				8	13.6	
		8	12.5				8	13.8	
	80	8	13.0	26.2		79	8	14.2	27.6
		8	12.2				8	14.8	
		8	12.5				8	14.8	
		8	12.5				8	14.8	
	80	8	13.0	26.4		78.5	8	15.2	27.2
		8	12.4				8	15.0	
		8	13.0				8	15.0	
80 kv.		8	12.5		80 kv.		8	14.8	
	79	8	12.5	26.4		79	8	15.1	27.0
		8	12.3				8	13.8	
		8	13.0				8	14.0	
		8	12.5				8	15.0	
	80	8	12.8	26.0		79	8	14.8	27.8
		8	13.0				8	13.8	
		8	13.0				8	14.8	
		8	12.5				8	13.8	
	80	8	12.5	25.8		79	8	14.0	28.0
		8	12.5				8	13.8	
		8	12.4				8	13.8	
		8	12.5				8	13.6	
	80	8	12.6	26.2		79	8	13.6	27.6
		8	12.8				8	13.8	
		8	12.5				8	13.8	
		8	13.0				8	13.6	
	80	8	13.2	26.0		79	8	13.8	27.8
		8	13.0				8	14.2	
		8	12.8				8	14.8	
		8	12.8				8	14.8	
	80	8	12.8	25.7		79	8	14.8	27.1
		8	13.0				8	14.0	
		8	12.8				8	14.8	
		8	12.8	25.9			8	13.8	27.2
Average...	80	8	12.8	25.9	Average...	79	8	14.2	27.4

Table showing the actual electroscopic and sphere gap reading taken during the exposure of spectra at 80 kv. and 8 ma. with each machine over a period of forty-five minutes. These readings over other voltages are shown in Table II.

spectra by means of a resetting device, which could be worked at a distance by a push button (Fig. 2). This assured us of having the spectra and electroscopic measurements of identically the same roentgen beam. This series of electroscopic readings also aided in keeping all of the other factors (milliamperage, voltage, etc.) constant, as it would indicate immediately any change in the various factors during the making of the spectra. Fifty to seventy-five readings were taken by this means at each voltage setting, and the readings quoted represent the average of this large number of observations (Table I).

A General Electric oscillograph was used to show the differences in wave form of the currents produced by the two machines. The high tension current waves were obtained in the usual manner by connecting the vibrator of the oscillograph across a small series resistance in the high tension circuit. The voltage waves shown were obtained directly from the primary of the high tension transformer by connecting another vibrator across the primary line, with a suitable resistance in series with the vibrator. As neither a potential transformer nor a suitable high resistance was available in the laboratory,

it was not possible to obtain tracings of the secondary voltage waves. The tracings shown are therefore not quantitatively interpretable, but are included merely to illustrate the difference in wave shapes and to show the utilization of both halves of the wave by one machine and the suppression of one alternation by the other.

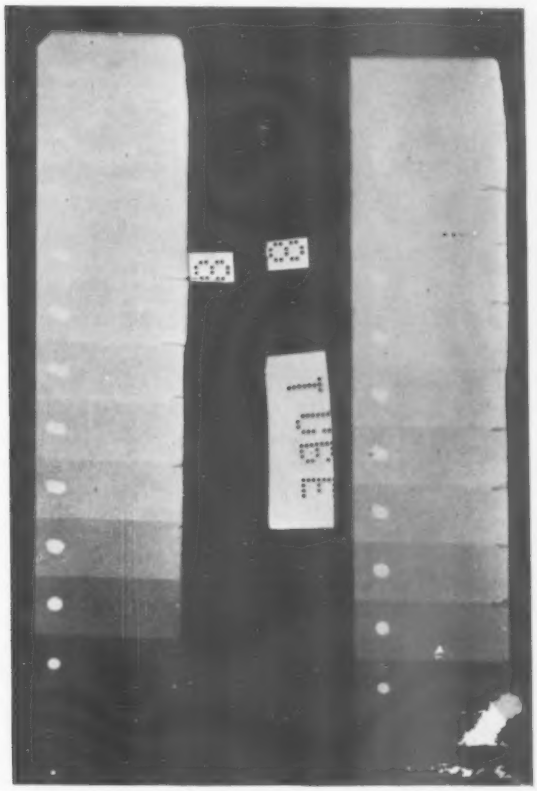

Fig. 3. Showing the series of aluminum steps exposed upon the same film at the same kilovoltage (80 kv.) and milliampere-seconds. Photometric measurements of the density of these steps are plotted in Chart 1.

Since the end-result of a roentgenographic machine is the film and since there was a possibility that the usual ionization measurements might not run parallel with the photographic effect, it seemed desirable to make some sort of comparison by roentgenographic means. For this purpose one-half of a film was made of a series of twelve aluminum steps (Fig. 3), or the aluminum steps and a specimen of some sort (Figs. 4 and 5), with each machine set at the same crest kilovoltage and milliamperage. Nothing was varied in either case except for the shifting of the film and the aluminum ladder or steps which were used for all of these tests. Various kilovoltages and milliamperages were similarly investigated. Plain films and films between double intensifying screens were used. As the exposures of the two machines at the same settings were made on the same film, the errors in darkroom technique were controlled.

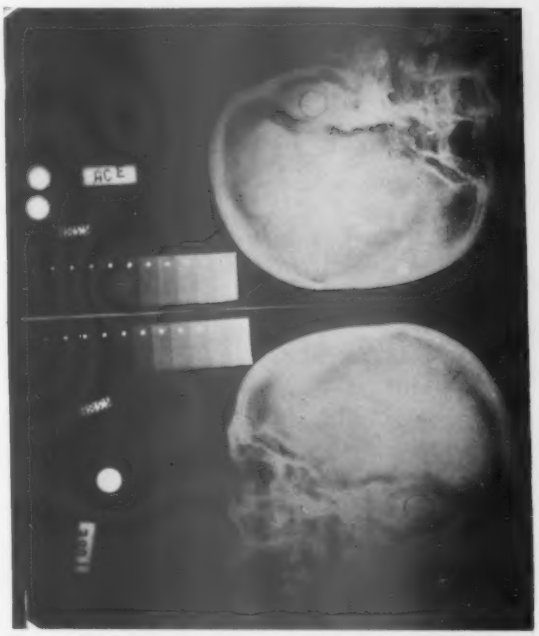

Fig. 4. Showing two exposures of a cadaver skull on the same 14 × 17 film using double screens without a Bucky diaphragm, 68 kv., 120 ma-sec. at 7 feet. The aluminum steps and the areas on the skull marked by circles were measured photometrically. There is a measurable but no visible difference in the films made by the valve tube (bottom) and the mechanically rectified machine (top).

Shearer[10] (1914) used a photo-electric cell and galvanometer for measuring film densities with good results when equal intensities were compared. We have found this to be a satisfactory method for this purpose. Various areas on the films were chosen and the galvanometer readings obtained. These readings, while they readily indicated which film was more exposed, were not directly comparable because the blackening of the film is a logarithmic function of the absorbed energy rather than being directly proportional to it (Chart 1).

In photographic terminology, density (D) is defined as the logarithm of the reciprocal of the fraction of the light transmitted (T) by the photographic deposit, i.e., $D = \log_{10} \frac{I}{T}$. For instance, if

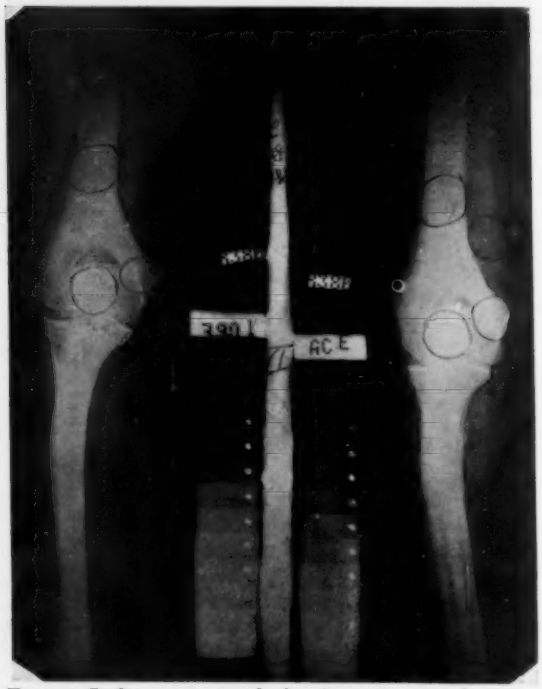

FIG. 5. Cadaver arm and aluminum steps taken at 7 feet, 200 ma-sec., 88 kv. on the valve tube machine (left), 86 kv. on the mechanically rectified machine (right); no filter, plain film. The circles show the areas measured for density. (See Chart II.)

the deposit transmits $\frac{1}{10}$ of the incident light, $D = \log_{10} \frac{I}{\frac{1}{10}} = \log_{10} 10 = 1$. If the deposit transmits $\frac{I}{100}$ of the light, $D = \log_{10} 100 = 2$. The useful densities in the average roentgenogram range from about 0.3 to about 2.0. If the transmitted light, $T = \frac{I_t}{I_o}$, where I_t is the intensity of the transmitted light and I_o the intensity of the testing light, then

$$\text{Density} = \log_{10} \frac{I}{I_t/I_o} = \log_{10} \frac{I_o}{I_t}$$

or the Opacity Logarithm. The two terms, Density and the Opacity Logarithm represent the same thing and are interchangeable.

To obtain the relation between density and exposure it is necessary to impress upon the film a series of known exposures and to measure the resulting densities. Density is customarily plotted against the logarithm of the exposure and this curve is known as the characteristic curve (Hodgson).[6] In the present experiments the roentgen-ray intensities being compared were nearly equal to each other and it was considered a sufficiently accurate approximation to assume that the roentgen-ray intensities were proportional to the resulting density, rather than to determine experimentally the exact relation between density and roentgen-ray intensity.

After a sufficient number of comparative readings with the electroscope and films had been obtained, further tests were made to eliminate characteristics of the individual machine. It is a well-known fact that transformer design affects the efficiency of a roentgen machine to a large extent. It is necessary to eliminate the effects of different transformer losses, resistance losses, etc., if one wishes to compare, for example, the relative merits of one type of rectifier with another (Bachem,[1] Voltz,[11] Heyde and Saupe[5]). Accordingly, the mechanical rectifier was stopped and short circuited and the valve tube connected in its place, after which a complete set of readings and spectra were taken.

Two complete and separate roentgenographic machines have been compared, using the same overhead system, tube and high tension measuring devices, by ionization and photometric methods. The differences due to machine design have been eliminated by interchanging the rectifying device.

DATA AND DISCUSSION

On the valve tube machine, the high frequency milliammeter read the same as the other meters. On the mechanically rectified machine, its readings were 10 to 20 ma. higher than the direct current milliammeter readings. The presence of high frequency currents is visible also on

the original oscillograms of this machine (Fig. 6), though the range of this oscillograph is hardly suitable for showing them clearly. We attempted to measure the "energy maxima" of these high frequencies with a "wave meter" but were unsuccessful. These currents are undoubtedly present in any type of mechanically rectified machine (Voltz,[11] Rieber,[9] etc.), and while they can be suppressed, their presence is not necessarily detrimental although they may, under certain conditions, influence the "gap" readings. They must be considered, however, a loss of energy, since they are non-productive of roentgen rays (Bachem,[1] p. 25). Since they do not register on the usual type of milliammeter supplied by the manufacturers of roentgen machines, they would not influence the current readings for comparative tests and in this sense can be disregarded.

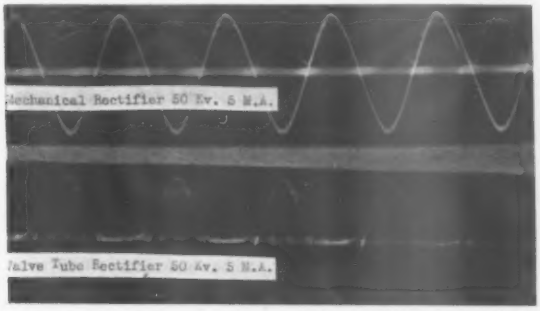

Fig. 6. Oscillogram with the primary voltage and the secondary current waves superimposed at 50 kv. and 5 ma. A line generator harmonic and the high frequency waves from the mechanical rectifier are shown on the current wave at this low current.

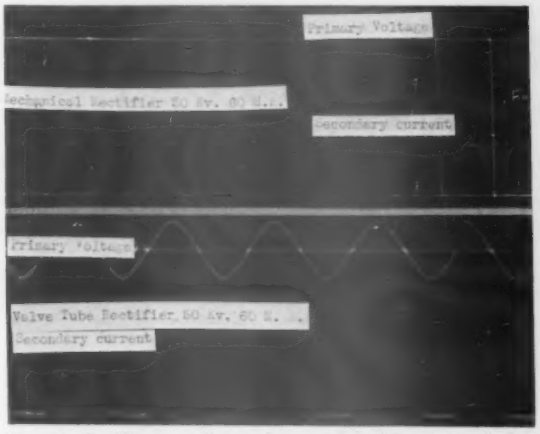

Fig. 8. Oscillogram from the two machines running at 50 kv. and 60 ma. showing the high tension current wave form with the mechanical rectifier (double wave) and the valve tube rectifier (single wave). The primary 60 cycle voltage wave is shown for comparison of the timing. The break in the curve represents the start and stop of the exposure.

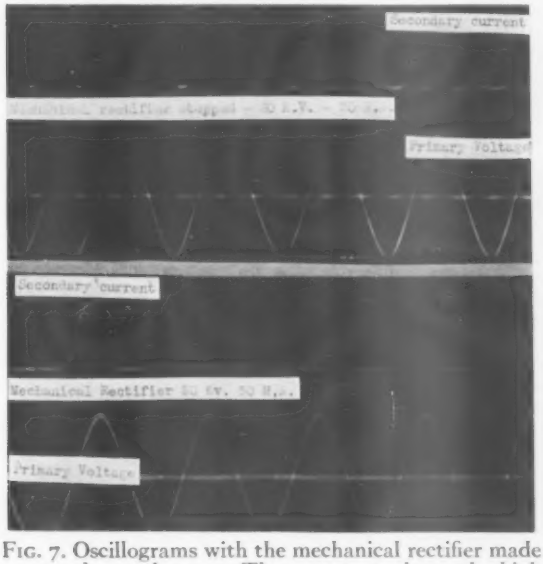

Fig. 7. Oscillograms with the mechanical rectifier made at 50 kv. and 30 ma. The upper one shows the high tension current form with the rectifier short circuited and the broad focus Universal Coolidge tube rectifying the current.

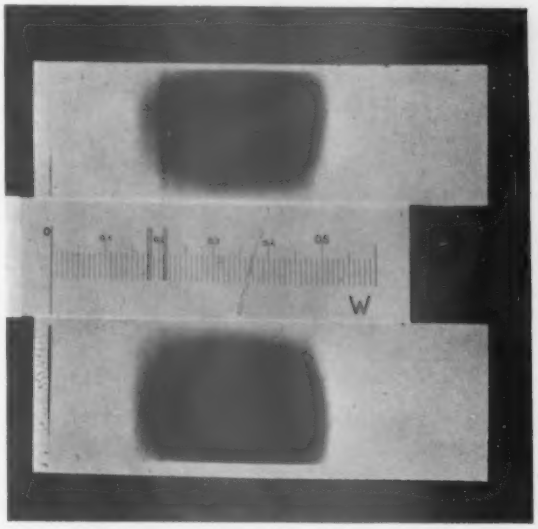

Fig. 9. Showing spectra made at the same time as the ionization readings plotted in Table 1; upper—valve machine at 79 kv.; lower—mechanically rectified at 80 kv.

The oscillograms are included merely to illustrate the difference in wave form

between the two types of rectifiers. It may be noted that the wave shape of currents from the valve tube machine is not essentially different from that of the self-rectified outfit (Fig. 7, upper curve), but of course the capacity of the valve tube rectified machine is much greater. Many authors have suggested that differences in the wave form of the high tension current is responsible for the marked variation in output of roentgen machines. The wave forms of the two machines tested here demonstrate a certain similarity in that the waves have a rather flat top and similar slopes. They differ in that the mechanical rectifier delivers twice as many impulses per second as the valve tube. Figures 6 and 8 show the changes in wave form with different loads. At the higher milliamperages the amplitude of the vibrator has been reduced in order to get the curves on the film. This reduction in size tends to eliminate small superimposed waves, such as those visible on the curves made at 5 ma. (Fig. 6).

Examination of the spectra taken at the different voltages shows good agreement between the two machines for the shortest wave length. The crest voltage is calculated from the formula,

$$\text{kilovoltage} = \frac{12.354}{\text{minimum wave length}}.$$

The sphere gap readings are consistent with the calculated kilovoltage (Table II). Figure 9 shows a reproduction of the two spectra made at 80 kv. The scale in Ångström units is included for comparison.

It is wise to include resistors in the sphere gap circuit to limit the current of the spark-over, and with this precaution, it is readily possible to obtain voltage readings on the valve tube rectified machine.

Since the absorption of roentgen rays

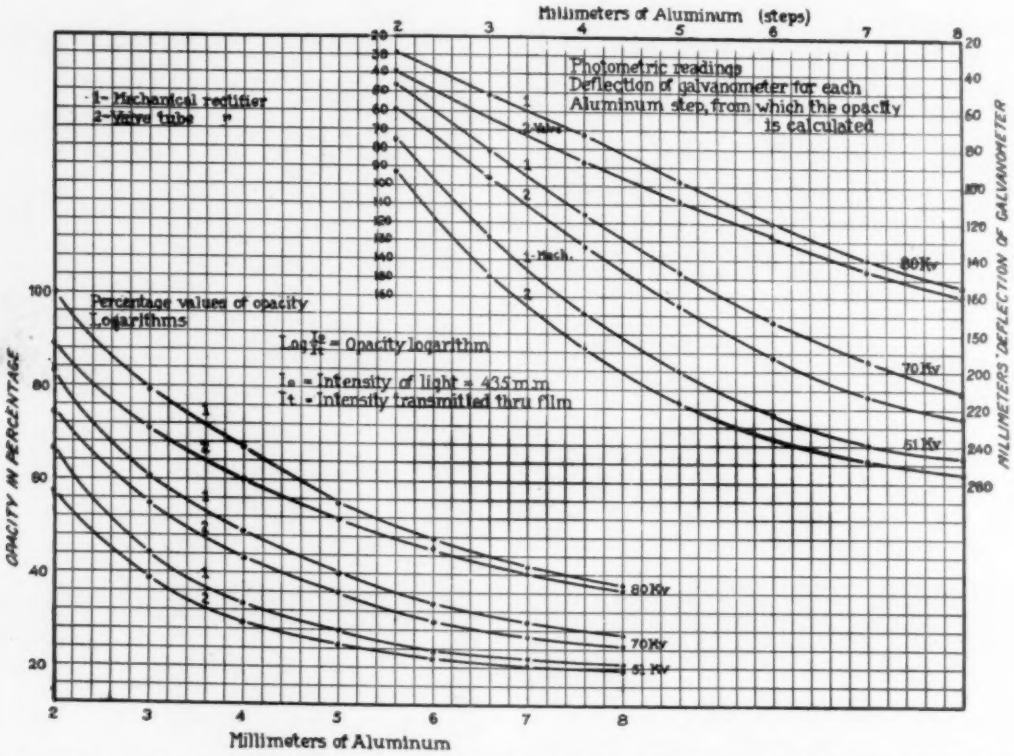

CHART 1. The upper curves show the photometric reading from the aluminum steps plotted directly; the lower curves, same data plotted as the opacity logarithm. The three pairs of curves represent three kilovoltages.

TABLE II

IONIZATION MEASUREMENTS

Machine	Calculated Kv.(Spectra)	Sphere Gap	Ma.	Average Intensity No Filter	Average Intensity 1 Mm. Al	Average Difference Per Cent
Mechanically rectified machine.....	80	80	8	100	100	8.0
Valve tube rectified machine.....	80	79	8	90	96	
M.....	59	61	10	100	100	4.5
V.....	59	60	10	96	95	
M.....	40	41.5	10	100	100	3.5
V.....	40	41.5	10	96	97	

PHOTOMETRIC MEASUREMENTS

	Kv.	Ma.	Filter	Maximum Difference Per Cent	Average Difference Per Cent
Mechanically rectified machine.....	80	10	1–12 mm. Al	11	7.5
Valve tube rectified machine.....	80	10	1–12 mm. Al		
M.....	62	10	1–12 mm. Al	9	6.5
V.....	62	10	1–12 mm. Al		
M.....	42	10	1–12 mm. Al	13	8.0
V.....	42	10	1–12 mm. Al		

Table showing the comparative measurements at various kilovoltages by ionization and photometric methods.

TABLE III

PHOTOMETRIC MEASUREMENTS

Machine	Kv.	Ma.	Filter	Mechanical vs. Valve Rectifier: Maximum Difference Per Cent	Mechanical vs. Valve Rectifier: Average Difference Per Cent
Mechanically rectified machine...	104	10	1–12 mm. Al	19	16.0
Valve tube rectified machine....	102	10	1–12 mm. Al		
M.....	86	80	1–12 mm. Al	− 5	− 2.2
V.....	88	80	1–12 mm. Al		
M.....	70	10	1–12 mm. Al	12	11.0
V.....	70	10	1–12 mm. Al		
M.....	51	10	1–12 mm. Al	13	8.0
V.....	51	10	1–12 mm. Al		
M.....	41	30	1–12 mm. Al	19	16.0
V.....	41	30	1–12 mm. Al		

Table showing the photometric measurements of various combinations of voltage and milliamperage using the aluminum steps for comparison.

by a film depends upon the "hardness" of the roentgen beam (Bachem[1]) as well as upon the intensity, "the photographic method can be used for comparing the intensities of two beams, . . . if the components of the beam are of the same hardness." There are certain departures from this rule, but if approximately equal intensities are used it is possible to place a relative value upon them. In a rough way, this is the principle of the Kienböck strips (bromide paper) for estimating dosage. Hodgson[6] has shown curves of the ranges of density for various exposure values and has demonstrated that over a certain range, the increase in density is proportional to the logarithmic increase in exposure. These readings cannot be utilized directly to identify any particular kilovoltage (Shearer[10]). In the manner in which we have employed them, namely, to compare two intensities of nearly the same order of magnitude, these density measurements are quite usable. It can be seen from Table II how closely they agree with the ionization (intensity) measurements for differences between the two machines at any particular voltage setting.

The composition of the roentgen-ray beam from each machine is probably somewhat different so that comparison by such density measurements might bring out differences in the composition of the roentgenograms. Direct inspection of the films, however, shows little difference in the appearance of the image, contrast between bone and soft tissue, etc. (Figs. 4 and 5). This was true whether plain films or double intensifying screens were used. Figures 4 and 5 show the several identical points picked out upon the two images, which were measured for density with the photo-electric cell and galvano-

meter. These densities show essentially the same differences established for the aluminum steps alone, in that they are consistently greater for the mechanically rectified machine than for the valve rectified machine (Chart II). This increase (Fig. 3), when plotted directly, or as the opacity logarithm (Chart I), indicate that the energy relationships of the two machines run uniformly parallel for the various voltages. Further studies with other voltages are shown in Table III.

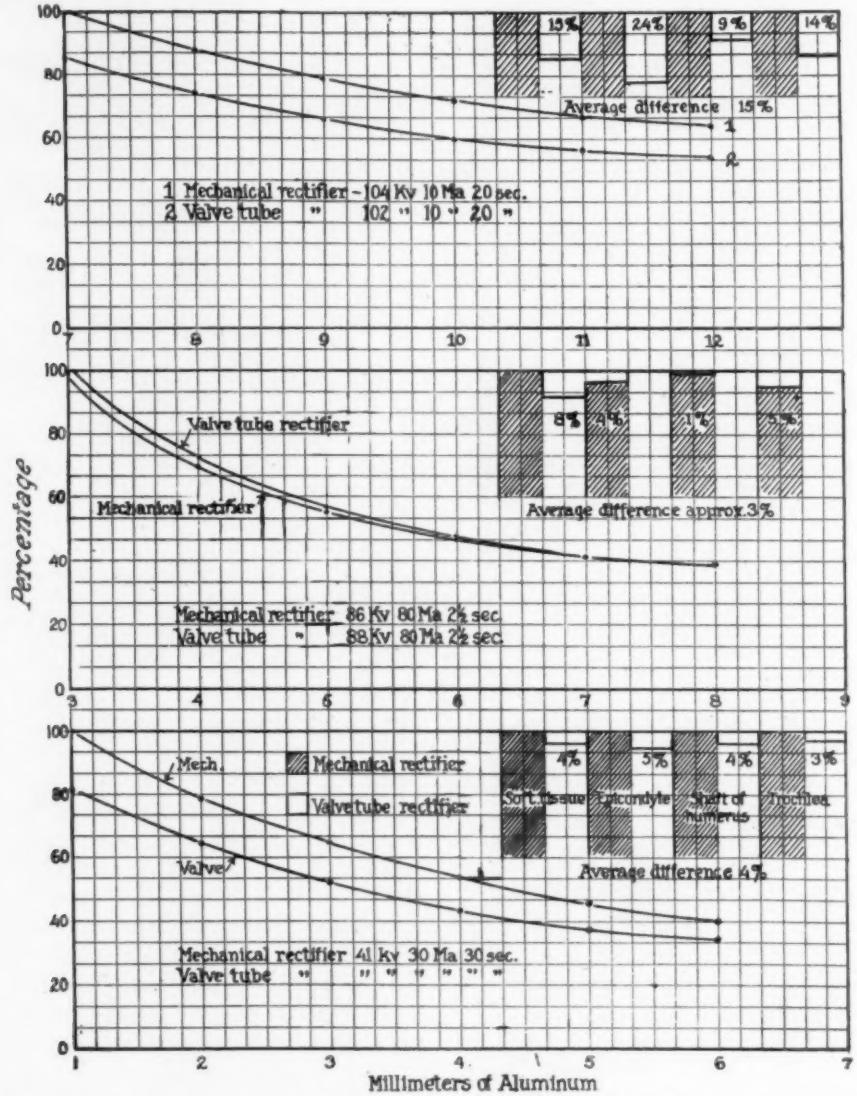
Percentage
Millimeters of Aluminum
Average difference 15%
1 Mechanical rectifier - 104 Kv 10 Ma 20 sec.
2 Valve tube " 102 " 10 " 20 "
Valve tube rectifier
Mechanical rectifier
Average difference approx. 3%
Mechanical rectifier 86 Kv 80 Ma 2½ sec.
Valve tube " 88 Kv 80 Ma 2½ sec.
Mech.
Valve
Mechanical rectifier
Valve tube rectifier
Soft tissue
Epicondyle
Shaft of humerus
Trochlea
Average difference 4%
Mechanical rectifier 41 Kv 30 Ma 30 sec.
Valve tube " " " " " " "

CHART II. Curves showing the photometric measurements of roentgenograms of the aluminum steps and various parts of cadaver arm (see Fig. 5).

in density is not visible upon first inspection. It is interesting to note that until it reached almost 15 per cent the differences in density between two roentgenograms were not appreciable to the unaided eye. The deflections indicating the density of the images of the aluminum ladders

It was observed that the adjustment of the sparking distance in the mechanical rectifier made a considerable difference in the efficiency of this type of apparatus. When first set up the output measured from 12 to 20 per cent lower than that of the valve tube outfit. This is graphically

shown in Chart III. Adjusted to its maximum efficiency, however, this machine's output increased until it exceeded that of the valve tube machine at equivalent settings (Chart III). Probably the mechanically rectified machine as used for this investigation was adjusted to a point of efficiency not always attained in practice. This is particularly true of mobile units, where parts of the rectifier may be loosened or separated by vibration. This may account for a great deal of the discrepancy, noted by various observers, in the output of various machines of the same capacity. Careful attention to this factor may increase quite markedly the output of many machines now in use.

When the valve tube was installed in place of the mechanical rectifier no consistent difference in output was observed. A slight variation was found in observations made several days apart, sometimes in favor of one, and sometimes in favor of the other rectifying device. The average variation was under 3 per cent and undoubtedly was due to difficulties in obtaining an exact adjustment of the kilovoltage. It would seem that the observed differences in the output of these two types of roentgenographic machines must be due to differences in design and efficiency of some part of the machine other than the rectifier. Concerning the useful life of a valve tube we have no data. Examination of the valve tube after a month of continuous use in these experiments showed almost no change in its appearance or its characteristics. Outside of the much mooted question of efficiency, the advantages and disadvantages of both types of rectifier are well understood, so that they will not be discussed here. We do not sponsor any particular type of machine but simply state the results of these tests on the efficiency of the two rectifying devices described here.*

SUMMARY AND CONCLUSIONS

When the same crest voltage and current from a roentgenographic machine, using either a valve tube or a mechanical rectifier, is applied to the roentgen tube, the output is practically the same. This has been demonstrated by ionization and photometric measurements.

The efficiency of the mechanical rectifier is dependent upon its phase relationship and the adjustment of the collectors.

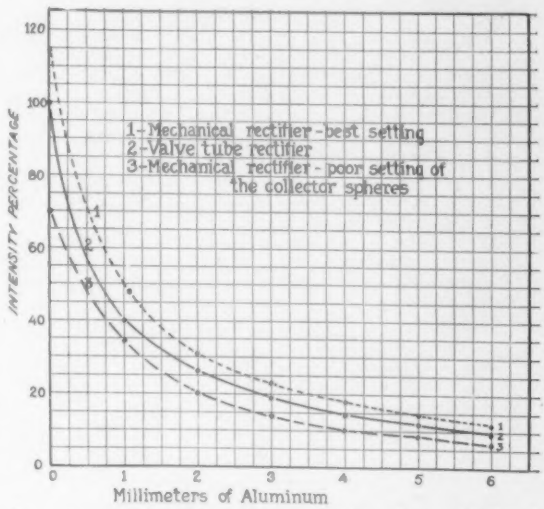

Chart III. Absorption curves showing the variation in output of a mechanically rectified machine when the collector shoes are not correctly set. The absorption curve of the valve tube rectified machine is included for comparison. Factors, 5 ma. at 60 kv.

Properly adjusted, the type of rectifier tested here gave a slightly but constantly greater output than the valve tube type of machine.

Other differences in the output of machines of this type and capacity probably arise from the losses in the individual control apparatus and transformers, as well as from normal variation in manufacture.

Wave form seemed to play no particular part in the observed output of these two machines.

There appears to be no essential difference in quality between films taken on either type of machine, and measured differences in density as great as 15 per cent are only barely apparent to the eye.

The photometric method of measuring roentgenographic energies is satisfactory provided that the composition of the beams and the radiation intensities are approximately the same. This method compares favorably with the ionization method for this purpose when certain precautions are taken.

* We are greatly indebted to Mr. R. B. Wilsey for his suggestions in connection with the use of the photometric methods described in this paper.

The sphere gap, contrary to some opinions, appears to be as satisfactory when used with a valve tube machine, as with a mechanically rectified machine, when properly safeguarded by suitable series resistance.

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A BASIS FOR DOSAGE DETERMINATION IN INTERSTITIAL IRRADIATION*

BY EDITH H. QUIMBY, M.A., AND HAYES E. MARTIN, M.D.

Memorial Hospital

NEW YORK CITY

UP to the present time, interstitial radiation therapy has rested on an empirical basis. This is partly due to the difficulty of obtaining exact information as to the distribution of the radiation within the tissues around buried sources. Calculations are difficult because of the lack of information regarding scattered and secondary radiation within the tissues. The instruments used in determining depth doses for external sources are too large and insensitive for this problem. It is therefore necessary for the clinician to determine the dose for a given case from previous experience with similar cases, or to use the maximum amount which he thinks will be tolerated in the particular instance.

Obviously, the application of interstitial irradiation can never be put on a strictly geometrical basis. Even if, in every case, the optimum dose and distribution of sources could be calculated, the actual insertion of the tubes could not be done to a definite specification. However, definite information on the distribution of buried radiation would indicate the most effective manner of applying any given empiric dose.

We wish to present data on the following points:

1. The distribution of the intensity of radiation around a single tube buried in tissue.

2. The distribution around groups of tubes. This includes a study of different spacings of the same set of tubes, of different numbers of tubes of the same strength, and of different numbers of tubes having the same radon content.

3. The best practical method of using radon in a given mass. When the dose has been decided upon, should the radon be concentrated at the center, divided into a

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few moderately strong, or many weak tubes, and how should these be placed so as to act most effectively?

4. The consequences of deviation from the exact placement aimed at.

We shall take up these points in order.

1. *The Distribution of Radiation Intensity around a Single Source Buried in Tissue.* It is obviously impractical to study this directly in human tissue, either normal or diseased, by experimentation, but other methods are available, and a good deal of research has been carried out on the subject. Cutler[1] has buried gold tubes of varying strengths in normal rabbit muscle, excised them after a suitable interval, and found the volume of necrosis due to a definite dose. Failla and Sugiura,[2] using the bleaching of butter as an indicator, have made other determinations of the radius of action of the tubes. One of us[3] has made similar determinations using wax blocks and the human skin erythema as an indicator.

The work mentioned above has all been done for the type of seeds in clinical use, that is, having a filtration of 0.3 mm. of gold, a diameter of 0.75 mm., and a length of 3–4 mm. The data from the various experiments have been found consistent, that is, the decrease of intensity with increase of distance from the tube is essentially the same for each method. Therefore they have been combined and a single curve obtained from the average results, which is given in Figure 1. The experimental work, the method of obtaining the curve, and its applicability to the dosage problems mentioned above, are discussed in a previous paper.[3]

We will briefly review here the method of using the curve. The ordinates represent percentages of the intensity of radiation delivered at various distances from the tube. The abscissas represent the distances. They are plotted in terms of an arbitrary unit, *a*, which is the distance at which, in any given case, a given tube will deliver a dose of 100 per cent. This 100 per cent does not mean an erythema dose, or a carcinoma dose, or any other definite amount. In any specified case, it means the dose we wish to deliver. The distance, *a*, will be different, of course, for different effects (erythema, necrosis, etc.), and for tubes of different strengths. But for any given tube, and any definite effect, if 100 per cent dose is delivered at a distance of *a*, then, according to the curve, at twice that distance (2 *a*), there will be 22 per cent of

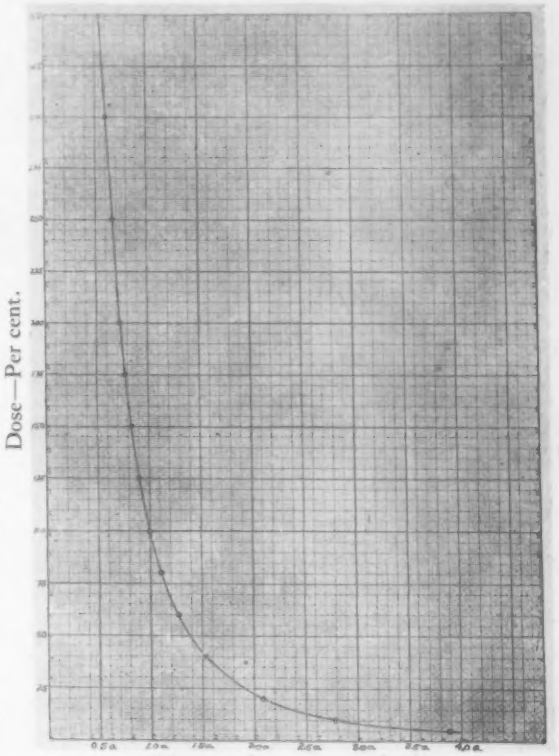

Fig. 1. Variation in radiation dose with distance from center of tube.

that dose. At half the distance (0.5 *a*), there will be 450 per cent, and so on. It is evident that to deliver a 100 per cent dose at a distance of 2 *a*, a tube almost 5 times as strong must be used. To deliver 100 per cent at 0.5 *a*, a tube less than ¼ as strong is sufficient. The actual strengths needed are in the ratios of the numbers on the curve, that is, at 2 *a* the tube to deliver 100 per cent is $^{100}/_{22}$ or 4.5 times as strong; at 0.5 *a* the necessary strength is $^{100}/_{450}$ or 0.45. For any other distance, the value can be found in the same way. Instead of taking as our standard tube, 1 millicurie, we may take *n* millicuries, where *n* may also take different assigned values for different effects to be produced. That is, for any particular effect, a tube of *n* millicuries will deliver 100 per cent dose

at a distance of a millimeters. For different effects both n and a will be different. For example, 5 mc. will produce necrosis in rabbit muscle to a distance of 3.1 mm. from the tube, in which case n is 5, and a is 3.1. Again, 6 mc. will bleach butter to a distance of 4.2 mm., in which case n is 6, a is 4.2. Inspection of the curve shows that 50 per cent of a full dose will be delivered at a distance of $1.4\,a$, so that in this butter example, 50 per cent would be delivered at a distance of $1.4 \times 4.2 = 6$ mm. In order to deliver 100 per cent at that point it would be necessary to have twice as strong a tube ($2\,n$, or 12 mc.) or to have two or more tubes contributing to the dose. A number of other examples are given in the paper already referred to.

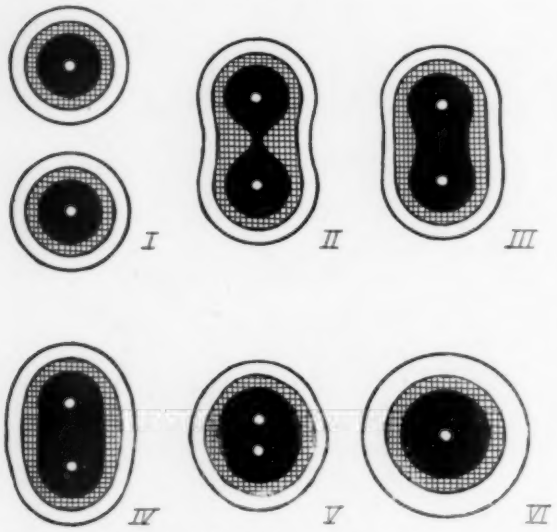

Fig. 2. Combined dose from two tubes at various distances apart.

If several tubes are to be used in a group, the contribution of each, and the total dose due to all at any given point may be calculated if the distance of each tube from the point in question is known. For example, consider a point so situated inside a triangle formed by three implants that it is $1.3\,a$ from one, $1.75\,a$ from another, and $2.2\,a$ from the third. Then it would receive from these tubes respectively 60, 30, and 17 per cent of a full dose, or 107 per cent altogether.

This is the method which has been used in the calculations in the present paper. For a single source, the limit of any given dose of radiation may be considered as a sphere. Since the source is a tube and not a point, this is not strictly true, but our experiments show that it is practically so. The limits of the zone of the dose we desire to deliver we call the 100 per cent zone. Outside this, the dose falls off rapidly, as the curve shows. The volume of tissue which receives less than 100 per cent is not benefited unless the dose is brought up to 100 per cent by adding more radiation. This may be done in several ways. The strength of the single tube may be increased or additional sources may be placed in its immediate vicinity. External radiation may, of course, be used, but that problem is not included in the present discussion. If the strength of the single source is increased, the increase in the 100 per cent radius may be determined from the curve. If additional sources are used, their contributions at any point may also be obtained from the curve.

2. *The Distribution of Dose around Groups of Tubes.* The simplest possible group is 2, and the distance of a point from each of two tubes can easily be determined. The combined effect of two tubes at different distances apart can be visualized by a series of diagrams, such as those in Figure 2. In each of these the white central portion represents the tube, the solid black parts, regions receiving at least 100 per cent dose; the shaded parts, at least 50 per cent, and the outer circle is the boundary of the 25 per cent zone. The first diagram, I, shows two independent tubes. In II, these have been brought together until their 50 per cent limits touch; in III, the 50 per cent limit of each reaches to the 100 per cent limit of the other; in IV, the 100 per cent limits touch; in V, the 100 per cent limit of each reaches to the other tube; and in VI, the two tubes are together. It will immediately be appreciated from a study of these diagrams how little use can be made clinically of the more irregular of the volumes defined by the 100 per cent zones. The combination IV might seem suitable for an elongated mass, but spacing only a little greater than intended would produce the hour-glass effect of the preceding diagrams, with inadequate irradiation to

the central portion of the mass. The combination v gives practically a spherical irradiated volume, and in vi the result is spherical.

Similar figures could be drawn for three tubes, but we will instead present an experimental result in this case. Figure 3 shows a photograph of tubes inserted in butter. Each of these contained 1.5 mc. of radon. For a tube of this strength, the 100 per cent radius for butter decoloration is 2 mm. The first three were so spaced that their 25 per cent limits touched; in this case the three bleached areas are completely separate. The next set were placed so that the 50 per cent zones touched. Here the three bleached areas coalesce, but leave an insufficiently treated spot in the center. The third group were spaced so that the 100 per cent zones touched, and the fourth so that the 100 per cent zone of each reached to the other tubes.

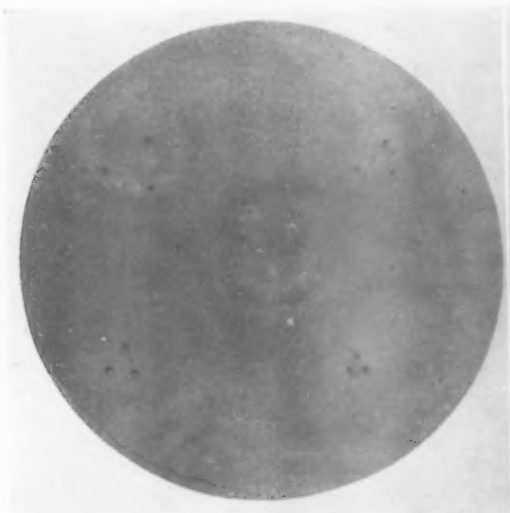

Fig. 3. Effect on butter of combinations of three equal tubes at different distances apart.

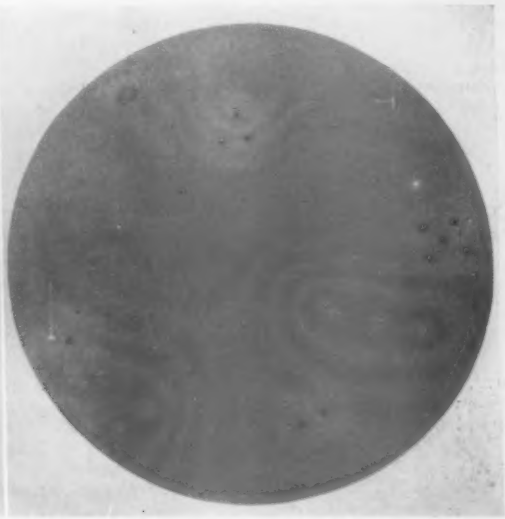

Fig. 4. Effect on butter of a given amount of radon divided among different numbers of tubes.

Two or three implants would of necessity lie in the same plane; greater numbers placed in a tumor mass seldom would. In fact, such placing would, in general, be highly undesirable. In clinical practice it is probable that much greater accuracy can be maintained if most tumor masses are considered as spherical. This means, in general, that an ellipsoidal mass will be treated as a sphere of diameter equal to the greatest axis of the ellipsoid. An irregular growth will be considered as lying just within the smallest sphere that will completely contain it, and this whole volume completely irradiated. A highly irregular or elongated mass may be considered as made up of adjacent spheres, rather than to include too much normal tissue. The effective dose need not be confined to the apparent volume of the neoplasm. Probably safety demands adequate irradiation well beyond this volume, in which case the larger volume is considered in the calculation of the dosage.

From the point of view of calculating the dose delivered within a mass, it is almost essential to consider spherical cases, and symmetrical placement of sources. Even so, the calculations become quite involved for more than a few sources. To use irregular spacings and volumes would be out of the question.

Having decided to irradiate spheres, questions arise as to the number, strength, and distribution of the implants to be used. Of course, for small masses, one implant will be used, placed at the center. For larger volumes, several may be used, and these should be grouped symmetrically about the center in order to obtain uniformity of irradiation. (Of course such symmetry is difficult to attain in practice, but it is an essential starting point for our calculations, and a desirable result to aim

TABLE I

Arrangement	Mc.	Radius for 100 Per Cent	Radius for 80 Per Cent	Radius for 60 Per Cent	Radius for 40 Per Cent	Distance of Tubes from Center	Volume per n Mc. for 100 Per Cent
1 tube	$1\,n$	$1.0\,a$	$1.1\,a$	$1.3\,a$	$1.5\,a$	....	$4.2\,a^3$
1 tube	$4\,n$	$1.9\,a$	$2.1\,a$	$2.3\,a$	$2.7\,a$	....	$7.1\,a^3$
4—tetrahedron							
side a	$4\,n$	$2.0\,a$	$2.1\,a$	$2.2\,a$	$2.7\,a$	$0.55\,a$	$8.4\,a^3$
$1.5\,a$	4	2.0	2.1	2.2	2.7	0.84	8.4
2.0	4	1.9	2.0	2.2	2.7	1.10	7.2
2.5	4	1.6	2.0	2.2	2.7	1.40	4.3
1 tube	$5\,n$	$2.1\,a$	$2.3\,a$	$2.5\,a$	$3.0\,a$	....	$7.6\,a^3$
5—tetrahedron with 1 at center							
side a	$5\,n$	$2.1\,a$	$2.2\,a$	$2.4\,a$	$3.1\,a$	$0.55\,a$	$7.6\,a^3$
$1.5\,a$	5	2.1	2.2	2.5	3.1	0.84	7.6
2.0	5	2.0	2.2	2.4	3.2	1.10	6.7
2.5	5	2.0	2.1	2.3	3.2	1.40	6.7
1 tube	$6\,n$	$2.2\,a$	$2.4\,a$	$2.7\,a$	$3.1\,a$	....	$7.3\,a^3$
6—corners of prism.							
Alt. and side a	$6\,n$	$2.3\,a$	$2.4\,a$	$2.8\,a$	$3.3\,a$	$0.77\,a$	$8.5\,a^3$
$1.5\,a$	6	2.2	2.4	2.7	3.4	$1.16\,a$	7.3
2.0	6	2.1	2.3	2.6	3.3	$1.54\,a$	6.5
2.5	6	1.7	2.0	2.5	3.3	$2.78\,a$	3.5
1 tube	$7\,n$	$2.4\,a$	$2.6\,a$	$2.8\,a$	$3.3\,a$	....	$8.4\,a^3$
7—as above with extra tube at center, alt. and side a	$7\,n$	$2.4\,a$	$2.6\,a$	$2.9\,a$	$3.5\,a$	$0.77\,a$	$8.4\,a^3$
$1.5\,a$	7	2.3	2.6	2.9	3.6	1.16	7.5
2.0	7	2.2	2.5	2.9	3.6	1.54	6.3
2.5	7	2.1	2.4	2.8	3.5	2.78	5.6
1 tube	$8\,n$	$2.5\,a$	$2.8\,a$	$3.1\,a$	$3.9\,a$	....	$8.3\,a^3$
8—cube, side a	$8\,n$	$2.6\,a$	$2.8\,a$	$3.2\,a$	$4.0\,a$	$0.87\,a$	$9.3\,a^3$
$1.5\,a$	8	2.5	2.8	3.2	4.0	1.30	8.3
2.0	8	2.5	2.8	3.2	4.0	1.74	8.3
2.5	8	2.3	2.7	3.2	4.0	2.95	6.5
1 tube	$9\,n$	$2.6\,a$	$2.9\,a$	$3.3\,a$	$4.2\,a$	....	$8.3\,a^3$
9—cube, 1 at center,							
side a	$9\,n$	$2.7\,a$	$3.0\,a$	$3.4\,a$	$4.3\,a$	$0.87\,a$	$9.2\,a^3$
$1.5\,a$	9	2.7	3.0	3.4	4.3	1.30	9.2
2.0	9	2.6	3.0	3.4	4.2	1.74	8.3
2.5	9	2.6	3.0	3.4	4.2	2.95	8.3
1 tube	$14\,n$	$3.2\,a$	$3.6\,a$	$4.5\,a$	$5.6\,a$	....	$9.9a^3$
14—							
8 at corners of cube, 6 at centers of faces,							
side $2\,a$	$14\,n$	$3.4\,a$	$3.8\,a$	$4.4\,a$	$5.4\,a$	$1.74\,a$ 1.0	$11.8\,a^3$
3	14	3.4	3.8	4.4	5.4	$2.61\,a$ 1.5	11.8
4	14	3.5	3.9	4.4	5.3	$2.48\,a$ 2.0	13.0
1 tube	$16\,n$	$3.4\,a$	$3.9\,a$	$4.9\,a$	$5.8\,a$	....	$10.3\,a^3$
16—							
2 concentric cubes							
inner $1.5a$ outer 3.0	$16\,n$	$3.5\,a$	$3.9\,a$	$4.5\,a$	$5.6\,a$	$1.30\,a$ 2.61	$11.4\,a^3$
inner 2.0 outer 4.0	16	3.3	3.7	4.3	5.4	$1.74\,a$ 3.48	9.5

TABLE II

Arrangement	Strength of each Tube, Mc.	Radius for					Distance of Tubes from Center	Volume per n Mc. for 100 Per Cent
		Total Mc.	100 Per Cent	80 Per Cent	60 Per Cent	40 Per Cent		
1 tube.....	1.0 n	1.0 n	1.00 a	1.1 a	1.3 a	1.5 a		4.2 a^3
	1.5	1.5	1.20	1.3	1.6	1.8		4.9
	2.0	2.0	1.38	1.4	1.8	2.1		5.6
	3.0	3.0	1.67	1.8	2.2	2.5		6.6
	4.0	4.0	1.89	2.1	2.5	2.8		7.2
	6.0	6.0	2.25	2.5	2.9	3.4		8.1
	8.0	8.0	2.50	2.8	3.3	3.8		8.3
	10.0	10.0	2.77	3.0	3.6	4.2		9.0
	16.0	16.0	3.60	4.0	4.7	5.4		12.3
4 tubes—tetrahedron side 2 a	1.0 n	4.0 n	1.9 a	2.0 a	2.2 a	2.7 a	1.10 a	7.2 a^3
	1.5	6.0	2.3	2.4	2.6	3.2	1.32	8.7
	2.0	8.0	2.6	2.8	3.0	3.7	1.38	9.3
	3.0	12.0	3.2	3.3	3.7	4.5	1.84	11.6
	4.0	16.0	3.6	3.8	4.2	5.1	2.08	12.3
	6.0	24.0	4.3	4.5	5.0	6.1	2.48	14.0
	8.0	32.0	4.8	5.0	5.5	6.7	2.75	14.1
	10.0	40.0	5.3	5.5	6.1	7.5	3.04	15.7
6 tubes—triangular prism. Side 2 a, altitude 2 a	1.0 n	6.0 n	2.1 a	2.3 a	2.6 a	3.3 a	1.54 a	6.5 a^3
	1.5	9.0	2.5	2.8	3.1	4.0	1.85	7.4
	2.0	12.0	2.9	3.2	3.6	4.5	2.12	8.6
	3.0	18.0	3.5	3.8	4.3	5.5	2.59	10.0
	4.0	24.0	4.0	4.3	4.9	6.2	2.90	11.2
	6.0	36.0	4.7	5.2	5.9	7.4	3.47	11.9
	8.0	48.0	5.2	5.8	6.5	8.2	3.85	12.4
	10.0	60.0	6.0	6.4	7.2	9.1	4.26	15.3
8 tubes—cube side 2 a	1.0 n	8.0 n	2.5 a	2.8 a	3.2 a	4.0 a	1.74 a	8.3 a^3
	1.5	12.0	3.0	3.4	3.8	4.8	2.09	9.4
	2.0	16.0	3.5	3.9	4.4	5.5	2.40	11.3
	3.0	24.0	4.2	4.7	5.3	6.7	2.90	13.1
	4.0	32.0	4.7	5.3	6.0	7.6	3.28	13.4
	6.0	48.0	5.6	6.3	7.2	9.0	3.92	15.4
	8.0	64.0	6.2	7.0	8.0	10.0	4.35	15.8
16 tubes—2 concentric cubes, inner, side 2 a, outer, side 4 a	1.0 n	16.0 n	3.4 a	3.7 a	4.3 a	5.4 a	1.74 a 3.48 a	10.3 a^3
	1.5	24.0	4.0	4.4	5.2	6.5	2.09 4.18	11.2
	2.0	32.0	4.6	5.1	5.9	7.4	2.40 4.80	12.9
	3.0	48.0	5.5	6.2	7.2	9.0	2.90 5.80	14.7
	4.0	64.0	6.2	7.0	8.1	10.0	3.28 6.56	15.8

at.) Two or three sources cannot be used in this manner; as already stated, they are more effective in one plane. Thus after a single source, the next combination to be used will be four, placed at the corners of a tetrahedron. The volume effectively irradiated by four sources of n millicuries each, thus arranged, has been worked out for several spacings of the tubes. This has been followed by symmetrical arrangements of 5, 6, 7, 8, 9, 14 and 16 sources. In any of these arrangements the actual volume receiving 100 per cent dose will not be spherical, but lobulated, but we have agreed to consider only the maximum sphere receiving this amount. Naturally this sphere will increase as the number of sources (of equal strength) is increased or as the strengths of the individual sources are increased, and the manner of this increase can be determined from the calculations just referred to. Table 1 gives a summary of calculations as the number of sources is increased. The first line in each

section of the table refers to a single source, of the strength indicated. The following lines in each section refer to groups of implants having the same total strength as the single one, placed symmetrically about the center, and at the distances apart indicated. The first four columns give the limits of spherical zones receiving at least 100, 80, 60, and 40 per cent radiation dose, in terms of our arbitrary unit, *a*. The next column gives the distances of the sources from the center, except in the specified cases where one source is at the center, and the last column the volume of the sphere receiving 100 per cent radiation.

The first conclusion which may be drawn from this table is that, for every group of implants, two or three of the spacings give a somewhat greater effective radius than the others. But it is also evident that there is quite a range of spacings in which approximately the same effect is produced. When the implants are placed farther apart than this, the effective radius decreases. Also, although it is not indicated in the table, when the spacing is increased, unless one implant is at the center of the mass, this central portion begins to be under-irradiated. The best spacing, in practically all cases, seems to be less than 2 *a*, that is, the 100 per cent zones of adjacent tubes should overlap.

We will next consider, instead of varying the amount of radon in a mass by adding more sources of equal strength, what happens when the same number of sources is used, but the strength of each is increased. These data are given in Table II. Each section in this table deals with the same number of sources similarly spaced but of several different strengths. A comparison of Tables I and II will show whether it is more effective to use a number of weak sources or fewer stronger ones. Apparently, from the point of view of the 100 per cent radius it makes little difference, a certain amount of radon will irradiate the same volume regardless of its division within certain limits. A particular example will illustrate this point.

Consider 16 *n* millicuries of radon divided in the five ways indicated in Table III. The 100 per cent radius is given in the last column, and it is seen that the maximum variation among them all is 6 per cent. This, of course, is too small to consider in this problem of interstitial dosage. The slight apparent increase for the smaller numbers of sources may indicate an advantage in their use, but it is too small to be definite.

Table III

No. of Tubes	Mc. Each	Total Mc.	100 Per Cent Radius
1	16.0 *n*	16 *n*	3.6 *a*
4	4.0	16	3.6
6	2.7	16	3.6
8	2.0	16	3.5
16	1.0	16	3.4

This illustration may well be supplemented by an experimental one. Figure 4 is a photograph of butter with gold implants inserted. The total strength of the tubes in each group is about 7.5 mc., in one, two, three and five tubes. Although the actual bleached area increases with the number of tubes, the largest circle (100 per cent radius) which can be inscribed in all of them is the same.

We may conclude, therefore, that, within practical limits, a sphere of definite radius will be equally well irradiated by one source or several, provided the several are symmetrically arranged about the center, and so spaced that their individual 100 per cent zones touch or overlap.

At once the question will arise as to what logical basis there can be for the use of multiple sources, necessitating multiple trauma for insertion, and the presence of multiple foreign bodies. We must, in order to answer this, consider what happens to the tissues which receive a dose greater than 100 per cent; 100 per cent is assumed to cause regression of the neoplastic mass. Some larger dose will cause necrosis; let us assume that this will be 500 per cent. We will now consider how the volume receiving 500 per cent dose will vary with the different divisions of our amount of radon, in the case of 16 *n* mc. just considered. It is first necessary to investigate whether the 500 per cent zones overlap, and we find that they do not, in any of the arrangements. (The calculations for this are omitted; they consist of direct application of the curve.) The

information concerning volume of necrosis is given in Table IV. The first three columns are taken from Table III. The volume for the fourth is the volume of the sphere having the radius given in the third. The volume for the fifth is the sum of all the small volumes around the individual tubes. Since this volume consists of different numbers of units of different radii in the different groups, the surface of the necrotic volume will be different. This has been calculated, and is given in the sixth column. The last column gives the surface per cubic centimeter of necrosis. Since absorption of necrotic matter takes place from the surface of the mass, the greater division of radon with correspondingly greater surface, is favorable.

TABLE IV

No. Tubes	Total Mc.	100 Per Cent Rad.Cm.	100 Vol. C.c.	500 Per Cent Vol. C.c.	500 Per Cent Surface Sq. Cm.	Surface per C.c. Necrosis
1	16 n	3.6 a^2	195 a^3	16.5 a^3	31.3 a^2	1.8 a
4	16	3.6	195	10.3	35.8	3.4
6	16	3.6	195	9.0	37.6	4.2
8	16	3.5	180	8.0	38.2	4.8
16	16	3.4	165	6.1	40.2	6.6

Obviously there must be some necrosis immediately surrounding any source of the strength used in clinical practice. In the average case the decrease in the volume and the increase in the surface of this necrosis seems to us a valid reason for a certain amount of division of the radon, and insertion of multiple sources.

Up to this point we have considered that the tubes will be inserted symmetrically into the mass, and that the exact placement desired will be obtained. Practically, this is seldom the case. If symmetry is not attained, the sphere receiving 100 per cent will be smaller than intended, and small deviations may be very important. Although we are considering for therapy only combinations of four or more implants, it will be easier to give an example in this case with three, since they can be shown in one plane. Figure 5 shows the zones of 100, 50 and 25 per cent dose around various combinations of three tubes. In the first, they are properly spaced, with the 100 per cent zones touching. The other three are arrangements which might be reached when trying to effect the first. The decrease in the effective radius is striking. It is evident that this possibility must always be borne in mind in planning dosage. It is generally impossible to give exactly the dose planned, hence the dose planned must be well in excess of the dose necessary to cause regression if it were accurately given.

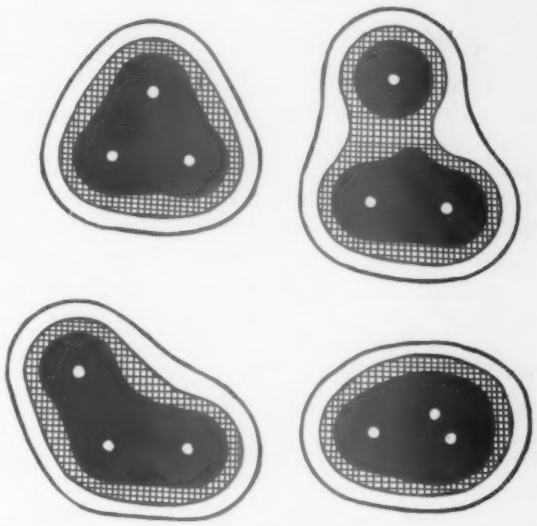

FIG. 5. Dose around symmetrical and asymmetrical arrangements of three tubes.

On the basis of Tables I and II we have prepared a list of the relative amounts of radon necessary to produce equal minimum doses in masses of different sizes. We have used diameters, rather than volumes, to define the masses, since it is much easier for the clinician to estimate the diameter of a mass. It must be noted that the amount of radon is not given in millicuries directly, but in multiples of n millicuries. That is, if n millicuries are sufficient for a

TABLE V

Diameter, Cm.	Dose, Mc.
1.0	1.0 n
1.5	2.5 n
2.0	5.0 n
2.5	7.5 n
3.0	11.0 n
3.5	16.0 n
4.0	22.0 n
4.5	30.0 n
5.0	38.0 n
5.5	48.0 n
6.0	60.0 n

mass 1 cm. in diameter, 5 times as much ($5\ n$) are necessary for a mass of twice the diameter, and so on.

Nothing in the above discussion permits of the direct calculation of the millicurie dosage for a tumor mass of a given size and nature. The dose of radiation necessary to produce regression in a tumor will depend on its radiosensitivity and other factors. The quantity of radon necessary to deliver this dose will depend on the size of the neoplastic mass. It is not possible at present to determine the exact radiosensitivity of a neoplasm and often the exact size must be estimated rather than measured. The actual dosage therefore must still depend largely on the judgment of the clinician. We believe, however, that a better knowledge of the distribution of buried radiation will permit greater efficiency with smaller dosage.

In this paper we have omitted all mention of the use of external irradiation as an adjunct to buried sources in delivering the desired total dose of radiation. We have in preparation another study of the combination of the two methods.

SUMMARY

1. The distribution of radiation about a single source, and about groups of tubes, buried in tissue, has been determined.

2. Tables are given for the increase in volume effectively irradiated with increase in quantity of radon. Results of increasing both the numbers of tubes, and the strengths of the individual sources are shown.

3. Around each tube is a zone of tissue which receives a 100 per cent dose. In order to irradiate a mass effectively with a group of tubes, these should be placed so close together that these 100 per cent zones are in contact.

4. From the clinical standpoint, it is best to consider all masses to be treated as spheres or as combinations of spheres.

5. A spherical mass is equally well irradiated with a given quantity of radon either concentrated at its center or distributed in one of several symmetrical groupings.

6. Conditions governing advisability of manner of division of dose are outlined.

7. If the desired symmetry is not obtained, the sphere actually irradiated will be smaller. Therefore, in order to be certain of adequate irradiation, overdosing is advisable.

8. A table is given showing relative amounts of radon necessary to irradiate spheres of different diameters to the same degree.

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ABSTRACT OF DISCUSSION

Dr. K. Wilhelm Stenstrom, Minneapolis, Minn. Radiation therapy has been developed in an empirical way. A certain dose was tried and when it was found insufficient it was increased. Because of this it is impossible to evaluate the dose readily. The only way this can be accomplished is to carry out definite experiments in which the dose can be measured. A number of such experiments have been carried out in the past, and most of these contributions have come from the Memorial Hospital in New York. This paper is another valuable link in the chain. We know from measurements how the distribution is around radium tubes filtered with a rather heavy filter, and we have had two such distribution charts from bulbs. From these we have been able to estimate to a certain extent the distribution around the implants but we cannot attain the accuracy that can be arrived at by measurements. For that reason such measurements are of great value.

It is rather surprising that the measurements indicate that the absolute distance from the tube is not of great importance, only the relative distance. That would be true if we had a knowledge of the absorption, and then only the relative distance would be of importance. It seems that this cannot hold true over the very large region for actual implants. Therefore, I suppose that the curve that the authors showed is limited to rather a small region and that it is not quite exact. I would like to know what they can tell us about this, what the experimental error is, and whether these things hold. Does it hold at 1 mm., and when we change "a" from 1 cm. to 10 cm. in order to do

that the other factors would have to compensate each other,—the factor of absorption, the factor of penetration of the rays as they go through more and more tissue, and the tubes; those three factors would have to compensate each other.

When it comes to deciding whether one tube or a number of small ones is best, I think we have to consider the shape of the lesion. If we consider that it is spherical the conclusion the authors brought out evidently should be correct, but it must be different when the mass is not spherical, and that would emphasize the point that it is better to use a number of small tubes than one large one. It is also better to irradiate the periphery of the lesion than the center, and for that reason also a greater number of small tubes would seem to be better.

Dr. Curtis F. Burnam, Baltimore, Md. The development of this work will mean a great deal in clinical results. We have all been at sea as to the irradiation in volumes in the body from implantations, and Dr. Stenstrom's remarks regarding the size of the volume are of great importance. If the ideal method is ever worked out in the laboratories it will only be by working with a great number of different shapes and volumes, that could be perhaps applied clinically. There will always be an inability on the part of the clinician to really plot out the volumes. When very short distances make such tremendous differences in the intensity of the irradiation we realize how very difficult it will be clinically to implant in a way corresponding to laboratory experimentation. I think the gold implants that can be removed are worthy of being tested out. One can put in the same gold tubes and give exactly the same amount of dosage as he would by surface applicator, and after a specified time remove them, thus removing the factor of depreciation from the problem.

Dr. O. L. Norsworthy, Houston, Texas. Three years ago, I exhibited an instrument for implanting radium needles. Such a needle implanter would be of great assistance in carrying out Dr. Martin's idea in the use of needles. It is important to have such an instrument graduated in centimeters. The needles can be placed parallel, perpendicular or at any angle and at any depth desired by the use of this implanter.

Dr. Martin (closing). The curve was obtained by a correlation of several series of experiments with gold seeds, such as butter decolorization, tissue necrosis in rabbit muscle, and human skin erythema through wax plaques. As to what distances it is applicable, we do not know, but have felt that it will apply at any distance ordinarily considered in interstitial irradiation. It would seem that the applicable distance in interstitial irradiation is a matter of a few centimeters anyway. The experimental error we think is too small to be very significant. The question of considering all masses treated by interstitial irradiation either as spheres or as combinations of spheres may sound rather peculiar, but measurements of interstitial dosage in irregular masses is practically impossible, except if such a mass be considered either as a sphere or as a combination of spheres. It would be very difficult even by the most careful measurements to determine exactly the limits of a neoplastic mass in, for instance, the tongue or tonsils, and a generous estimate of the sphere of tissue to be treated which includes the lesion would be much safer. As to whether the center or the periphery is most important, from the standpoint of treatment, I would say that they should be considered equally important, and from our experiments we have shown that a mass can be equally well irradiated whether the radon is placed at the center or distributed symmetrically throughout the mass. Dr. Norsworthy's needle for inserting seeds probably would be very helpful, provided that we could be certain of the depth at which the tumor mass is located, but I question such a determination at a depth of 10 cm. or even much less.

RADIOTHERAPY IN CHRONIC MYELOGENOUS LEUCEMIA*

BY EUGENE T. LEDDY, M.D.

Section on Roentgen-ray Therapy, The Mayo Clinic

ROCHESTER, MINNESOTA

CHRONIC myelogenous leucemia, a disease of unknown origin, usually classified with the lymphoblastomas, produces progressive anemia, enlargement of the spleen, and degenerative hypertrophy of the bone marrow, and results in an increase of immature leucocytes in the circulation. Men in the third and fourth decades are most commonly affected although it may rarely be found in young persons. Steinbrink in 1925 noted in the literature only 33 cases in young persons. He reported a case of his own in a child aged twelve years. Ramsay analysed 19 cases in children.

Like the other diseases of the lymphoblastoma group, myelogenous leucemia is characterized by a natural progression to a fatal end in spite of all treatment. The rate of this advance is subject to wide variations, some cases being much more acute than others. The average duration of life, according to the investigations of Minot, Buckman and Isaacs, Klewitz and Schuster, Keymling, and Fricke is about one and a half to two and a half years. Giffin stated that his data did not lead him to conclude that radiotherapy caused the disease to run for more than its usual course of from two to three years. Rénon, Degrais and Desbouis, Béclère, Holthusen, Vogel, Cabot and many others agree that the duration of life on the average is only a few months longer in the treated cases, and in the majority of instances it is from two to three years. It is best to regard isolated reports of cases in which patients were living five years and longer as naturally more chronic types of the disease.

It is well known that the application of correct radiotherapeutic procedures to properly selected cases brings about striking remissions of symptoms, so that patients who may be in distressing or even serious condition can be returned to a useful and functionally efficient existence. Forssell and Walterhöfer stated that definite improvement results in 90 per cent of cases. This improvement manifests itself not only in the blood, but in the phenomena secondary to leucemia, especially in the splenic tumor, and the general condition as a whole. In about 50 per cent, according to most authors, a remission is produced sufficient to make the patient free of symptoms, and able to work almost to complete capability whereas in the nonirradiated cases remissions occur in only about 6 per cent.

The great value of radiotherapy was established by the report of Senn who first undertook the treatment of myelogenous leucemia with roentgen rays of long wave length. Based on the well-known researches of Heinecke on the effects of irradiation on the blood-forming organs, the reports of Rénon in France, Schüller in Germany, and Ordway, Peabody, Giffin and many others in this country have established the value of radium in this disease. These reports have often been elaborated and substantiated, so that there remains little doubt that radiotherapy is the best treatment for this type of leucemia. Uncertain as are the theoretic foundations on which such treatment is based, nevertheless the beneficial action of irradiation on both the blood and the clinical picture is an actual therapeutic accomplishment.

The precise value of radiotherapy, however, is difficult to establish, for many of the reports in the literature are hard to evaluate statistically. Many of them are based on a small number of cases, so that the factor of accidental finding, or of coincidence cannot be eliminated. In only a fraction of them are such data as the number of definitely diagnosed cases, the duration of observation, the technique of treatment and so forth, given in any detail. There is surprisingly little infor-

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mation concerning such facts as the natural duration of myelogenous leucemia, or of the length of time radiotherapy enables patients to remain efficient. Statistics concerning the effects of treatment on the symptoms of the disease, or on its course are very meager, but general statements are common, and papers presenting various aspects of from one to five cases are common. The result is that medical and surgical measures have been found to be of little avail in the treatment of this disease, and the only one that has been found to be really useful is radiotherapy. Even though myelogenous leucemia remains as incurable as ever, the outlook for the patient, although still ultimately hopeless, is not immediately so desperate, for radiotherapy has been proved to be a means of relieving most patients for an indefinite period.

The response of myelogenous leucemia to radiotherapy is prompt and definite because of the type of cells characterizing it, and because of the hyperplasia of the hematopoietic system as a whole, and is a complete confirmation of the law of Bergonié and Tribondeau concerning the radiosensitiveness of embryonic, immature, rapidly developing cells. As a result of their great sensitiveness, the number of immature cells of the myeloblastic series fn the blood may drop as much as 100,000 ior each cubic millimeter following mild doses of roentgen rays or of radium to the spleen or bone marrow, with corresponding decrease of the splenomegaly and improvement in the patient's general condition.

Unfortunately, most patients come for radiotherapy only when the disease is well advanced. It may well be that early recognition of the disease, and early institution of treatment may prevent further progress. However, most patients when they apply for treatment have reached such an advanced stage that there is serious impairment of health, secondary changes in the heart and circulatory system, serous effusion into the thoracic and abdominal cavities, and severe pressure symptoms with digestive disturbances from severe splenomegaly. In many cases the onset is not acute, so that in chronic cases the disease may cause only mild, if any, symptoms for several years before a diagnosis is made.

The technique of application of roentgen rays and radium in the treatment of myelogenous leucemia is subject to almost chaotic variations in the literature, to which the reviews of Wittkowsky, Dautwitz, and Bardachzi called attention, and is still in a state of flux, each therapist apparently advocating his own system to the exclusion of all others. Klewitz, Parrisius and Naegeli advocated irradiation of the spleen alone with roentgen rays. Schmitz and Tomanek stated that it should be irradiated with radium. Stengel and Pancoast advocated treating the bones exclusively with roentgen rays. Loucks stated that such a procedure is useless and advocated treatment of the spleen only. Bradley treated all the bones with gamma rays of radium in the form of a pack at a distance of 6 cm. Bowing and others have advised conservative treatment by a combination of radium to the spleen and roentgen rays to the long bones. Duke, Jenkinson, and others have avoided irradiation of the spleen and bones and have devoted their attention to treatment of the thoracic cavity. Irradiation of the spleen followed by splenectomy has been advised, and condemned. Certain authors, Schittenhelm and Meyer-Betz, Hirschfeld and Rosenthal, used high doses, even such as those of "Tiefentherapie." Ernst advocated mild doses, cautiously applied. Schreiner and Mattick and Klieneberger recommended an intermediate technique, with about three-fourths of a skin unit dose to the bones, Hohlweg and Pulawski reported a combination of radiotherapy with benzol and arsenic. David and Morawitz administered, also, some of the other radioactive elements such as thorium. Hirschfeld and Gotthardt irradiated the endocrine glands in addition to thorough treatment of the blood-forming organs. Nevertheless, in spite of all this difference of opinion concerning the method of treatment, the radiotherapy of myelogenous leucemia should be governed by certain well-established considerations, such as have been outlined by Desjardins in the treatment of other diseases in the lymphoblastoma group.

The blood-forming elements in the spleen and bone marrow, and the immature cells in the circulation in this disease, are, next to the lymphocytes and genital cells, the most sensitive in the body, especially since they are in a state of active reproduction and hyperplasia. Thus, mild doses of irradiation will produce marked decrease of these immature elements. However, the cells of the myeloblastic series, although at first extremely sensitive to irradiation, gradually become more resistant after repeated treatments, until finally they respond hardly any, if at all. Whether this refractoriness is due to connective tissue or to cellular resistance is unknown.

As has been indicated, either radium or roentgen rays may be applied in treatment. In the majority of instances the treatment can be carried out by a combination of physical agents and it should be under rigid clinical control. The aim is to produce destruction of as large a number as possible of the parent cells and immature leucocytes with as little systemic damage as is consistent with the clinical findings in a given case. At first the effect of such treatment is both rapid and spectacular. The enlarged spleen diminishes rapidly, the leucocyte count drops, and corresponding improvement follows in the patient's general condition.

After a thorough course of mild irradiation, which should include both the spleen and the bone marrow, the splenomegaly and the leucocytosis may no longer be demonstrable. It is not unusual for a huge spleen filling the entire left side of the abdomen to return to normal. Nevertheless, after a time fresh evidence of activity and hyperplasia of the blood-forming system becomes apparent: the first manifestation may be the reappearance of myeloblastic cells in the blood smear, together with an increase of the total leucocyte count. This recurrence may take place after a few or many months of clinical and hematologic well-being, and its response to irradiation of a given intensity and quality is not as good as formerly. With subsequent treatment of recurrences the abnormal cells take on increased tolerance to irradiation until finally any treatment fails to influence the pathological process.

If the radiotherapist uses intensive treatment at the outset, he may produce most gratifying immediate regression of the morbid processes, and obtain marked symptomatic improvement. But there is no definite evidence to support the view that strong initial irradiation of short wave length will postpone recurrences any further or give greater relief in the interval of freedom from symptoms than is obtainable with rays of only moderate penetration and intensity. Later, in the inevitable stage of refractoriness, treatment of the initial type will not be effective. Such an impasse may necessitate raising the intensity of irradiation, even to the point of the abandonment of roentgen rays, and recourse to the use of gamma rays of radium. The same impasse obtains with the preliminary use of radium, and for the same reasons. Since radiotherapy has not been proved to prevent the fatal outcome of myelogenous leucemia, no matter how it is applied, it seems best to save the heaviest forms of treatment until the lighter ones have exhausted their effectiveness.

At the outset the treatment should be general, and should be directed not only to the enlarged spleen, but also to the thorax, and to the marrow of the long bones. The intensity of dose for each treatment field is a question best settled by clinical experience and the merits of the individual case. In view of the nature of the disease it can safely be assumed that the whole blood-forming system should be treated since it is all involved in the pathological process.

Such treatment had better be carried out slowly, and be carefully controlled by both the blood count and the patient's general condition. An enlarged spleen, or a leucocyte count of about 20,000 with a satisfactory or stationary status of the patient, are in themselves not indications for further radiotherapy. In any event, when the treatment has produced its maximal or satisfactory effect it should be discontinued; a further drop of leucocytes may continue for some time after the interruption of treatment, a fact which should not be lost sight of, and the patient should be kept under periodic observation. This should consist in careful and complete

determination of variations in the size of the spleen, and of the level of the blood count, together with a differentiation of its elements. Fresh activity, manifested by enlargement of the spleen or a rise in the total leucocyte count, with reappearance of immature cells, if accompanied by a deterioration of the physical condition of the patient, no matter how slight, indicates immediate renewal of radiotherapy.

It is unwise to allow the patient to omit such periodic examinations, or permit him to have recourse to medical examination only on the reappearance of his symptoms. Since pain is only a minor symptom of this disease, since the onset and evolution of the process are so insidious in most cases, and since patients usually consider themselves in good condition as long as they are free from pain or actual distress, they should be strongly impressed with the necessity of a thorough periodic examination if they are to remain at their greatest physical efficiency.

With the introduction of deep therapy there has been a tendency to too great usage of rays generated at high voltage. In fact, as has been mentioned, certain authors have incorporated in the treatment of myelogenous leucemia the conceptions of "karzinomdosis," and their intensively destructive techniques. Radiotherapy of great intensity and of short wave length may produce rapid regressions, but since its end-results can be duplicated clinically and hematologically by roentgen rays generated at moderate voltages, the latter are distinctly preferable at the outset. For this reason it is probably better to begin radiotherapy with roentgen rays generated at 130 to 140 peak kv. and a filtration of 4 to 6 mm. of aluminum, with the reservation of high-voltage roentgen rays for possible use in the refractory period which is destined to occur in the usual course of the disease.

With intensive doses of roentgen rays or radium it is true that the result may be reached in less time than with mild doses, but the regression and apparent improvement may not be to the best interests of the patient. Not only is the toxic upset, in the form of nausea, vomiting and prostration, proportional to the effective dosage of irradiation applied at each session, but the danger of producing aplastic anemia is increased. Whether the greater amount of connective tissue which certain authors claim is produced by radium rays is of greater therapeutic value than the less intense sclerosis resulting from "softer" radiation is an open question. As there is no irrefutable evidence in support of the biologic superiority of irradiation at short wave length in such cases, nor of its greater selective absorption by lesions of this type, it is better to avoid the possibility of injuries inflicted by the use of intensive doses, and confine treatment to the technique which is least dangerous and clinically most effective.

It has been suggested by certain authors that early radiotherapy may lead to shortening of the patient's efficiency, if not of his life. Minot said the most plausible explanation for the comparatively short duration of life of patients treated within six months of the onset of symptoms is that those destined to have a short course usually have a stormy and impressive onset of symptoms, which leads to earlier diagnosis. This results in treatment earlier than in cases of myelogenous leucemia of a more chronic type, naturally progressing more slowly and more quietly, and in which definite symptoms develop later. Hence, diagnosis in this group is made later and treatment is started later.

It is possible that treatment begun very early may lengthen appreciably the duration of efficiency and life expectancy of patients suffering from a less malignant type of the disease which naturally runs a slower course, or that technical improvements in radiotherapy will bring about such a desirable state of affairs, but no available data permit such a conclusion.

CONCLUSIONS

1. Myelogenous leucemia, like the other lymphoblastomas, is generally fatal in from two to three years in spite of any form of treatment.

2. Radiotherapy will produce remissions in at least 50 per cent of cases for an indefinite period, even to the point of freedom from symptoms.

3. The treatment of myelogenous leucemia is best started with slow irradiation of both the spleen and the body generally.

4. High doses of radium and roentgen rays are better reserved for the treatment of the inevitable stage of refractoriness.

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ABSTRACT OF DISCUSSION

Dr. Henry J. Ullmann, Santa Barbara, Calif. I agree absolutely with the technique of Dr. Leddy, but we must not confuse large and small intensities with long and short exposures. If we admit that the wave length has no difference in effect, the effect being proportional to the absorption, it will not make any difference in the intensities whether we use 200 or 120 kv. It is sometimes easier to use the large dose and short period rather than the other. I think Dr. Pancoast first

described the method of irradiating the bones. My 100 per cent dose is that which will kill 90 per cent of *Drosophila* eggs after the method of Packard. We use 10 per cent of this, starting on the feet, then the ankles, hips, shoulders, and spine, and take blood counts every five to eight days. When the count falls to 15,000, we stop to see if it will go any further. We have found that it does not drop so far after stopping irradiation with the smaller doses as with the larger. One can absolutely ignore the skin effect with this 10 per cent fractional dosage at 200 kv. with copper filtration.

Dr. Walter Mattick, Buffalo, N. Y. We have found that there is not much difference whether we use low voltage or high voltage roentgen rays. The results are about the same. We have also found it better to use larger doses than the speaker recommended. Our procedure is to treat over the enlarged spleen, neglecting the bones, as a rule, and regulating the dose according to the blood count, as Dr. Leddy has told us. We have gone as high as a 50 per cent dose over the anterior and over the posterior region of the spleen, and have seen great improvement. When we reach a count of 15,000 to 20,000 we usually stop.

We should not neglect the medical measures, such as injections of cacodylate of soda, and other medical means of treating symptomatic needs in these cases. If we neglect the cacodylate of soda, anemia often develops. In the aplastic type of leucemia or aleucemic leucemia the red blood count is very low, the myelocytes are low, and you think you are dealing with anemia rather than a leucemia. These cases are very difficult to treat because of the low red blood count.

Dr. George E. Pfahler, Philadelphia. I treated my first case of leucemia by applications over the spleen. I got rather brilliant temporary results. I then started a series of cases over the long bones, and got the same results. I then came back to treating the spleen, with about the same results again. Splenic applications involve much less treatment and much less expense, and since my results are practically the same I have rather settled down to this method.

Dr. H. H. Bowing, Rochester, Minn. I wish to emphasize the importance of clinical observations. Our cases are usually referred for treatment. As soon as the application is made the patient is immediately returned to the clinician in order that the period of observation may be continued. We usually apply three treatments in two weeks. The universal silver tube applicator containing 50 mg. radium element is used filtered through the wall of the applicator and 2 mm. of lead, and maintained at a distance of 2.5 cm. The usual treatment time is twenty-four hours; two areas of twelve hours each. When the general condition is poor we may treat only one area for six or eight hours. I believe that when the general condition is poor the reaction is more severe, and it is not wise to overburden these patients. When the glands are large, as well as the spleen, the twenty-four hour treatment is divided into eight areas of three hours each. In myelogenous leucemia the radium treatments are supplemented by roentgenotherapy to the osseous system, as Dr. Leddy has reported. I think the idea that palliation is all that can be expected should be remembered, and the patient should not be over-treated.

Dr. Leddy (closing). I think at present it is an open question whether the biological effects of equal doses of radiations of long and short wave lengths are the same. There is much evidence against the acceptance of such a view and many therapists feel that the quality of a dose of radiation is as important as the quantity. The clinical dose used in any given case is largely a matter of experience and the technique should be carried out under the control of the factors we are dealing with. In this group of patients it is immaterial whether one begins with roentgen rays to the spleen or with roentgen rays to the bones. If one groups myelogenous leucemia with the lymphoblastomas, one should treat all the blood-forming areas and it does not make much difference where one starts, but if one uses large doses of high voltage roentgen rays or highly filtered radium at first, one has nothing to fall back on at the inevitable time when the disease becomes refractory. No matter what the factors of our treatment may be the result is eventually the same, fatal in all cases, but the technique I have described does give remission of symptoms.

STUDIES OF THE THYMUS, WITH ROENTGEN FINDINGS*

BY CHARLES W. PERKINS, M.D.

United Hospital

PORT CHESTER, NEW YORK

So much controversy has arisen during recent years in the study of the thymus that it is not the effort of the writer to establish new theories or any one fact positively, but an attempt is made to review certain well-known facts relative to this gland which are often disregarded and if possible define more accurately conclusions which are being formulated with uncertainty by many clinicians.

In the middle of the seventeenth century Versalius and Bartholinus gave the first pictures and descriptions of the thymus and since then it has been the subject of much controversy, speculation and theory. Thymic death is not by any means a new subject for Morgagni's investigation proved it was possible two hundred and fifty years ago. Many generations since then were taught that this gland was the center of courage and affection (thymos), that it was a supplementary organ of milk secretion, that its nervous origin was linked with the medulla; then again it was called a lymphoid and epithelial organ. So-called cavities in its structure now known to be artifacts, were the subject of serious attention by anatomists late in the eighteenth century. The history in relation to this organ may therefore be considered of highest importance.

The thymus is derived embryologically from a prolongation of epithelium of the third and occasionally of the fourth bronchial cleft. The close relationship in its development with the parathyroids and the thyroid accounts for occasional thymic inclusions in the thyroid and to some extent probably for the association of hyperthyroidism with thymic enlargement in some patients. The cells of the cortex are considered largely lymphocytic but in the medulla the lymphoid cells are not so frequent and here are found distinctive Hassall's corpuscles which Hammar has considered as derived from the reticular cells of the medullary substance which are of an epithelial origin. Authors who look upon the thymus as a lymphoid organ are divided into two groups, one believing that epithelial cells of which the gland is at first chiefly composed undergo transformation to thymic cells resembling or identical with lymphoid tissue; the other, that the organ is essentially lymphocytic as the result of invasion of lymphocytes from the mesentery.

That the nuclein content of the thymus is five times richer than the lymph nodes was shown by Ivor and Bangs in 1904 and that the phosphorus in the gland is correspondingly high; the rôle of the gland in phosphorus metabolism can easily be compared to function of the thyroid in the use of iodine.

Anatomically, Hammar has divided the thymus into three types according to location—the cervical, thoracic and the cervico-thoracic. The thoracic type is usually seen in man, yet very often the cervical portion is of exaggerated formation. In its relations the organ is in contact with the sternum anteriorly as low as the fourth intercostal cartilage. Posteriorly the thymus lies upon the right auricle and may touch the esophagus and tracheal bifurcation with attachment to the left innominate and approximation to the vagus and inferior laryngeal and phrenic nerves, particularly the right. The pericardial sac and posterior surface of the thymus capsule are usually adherent. The arterial supply is said to be richer than the venous drainage, and there is ample lymphatic drainage by which any secretion of the gland may finally reach the blood stream. Essentially the thymus belongs to the period of most rapid growth and development. From birth to two years the weight of the thymus ranges from 7–10 grams, glands of 20–30 grams in the first year being regarded as hyperplastic. Some authorities believe that the size is greatest at two years; others, at puberty. Hoskins

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has shown that in its ratio to the body size the gland is seven times as large at birth as at puberty. Considerable divergence in the weight figures given by different investigators is seen.

Hammar in Osler's "Medicine"

At birth	12.0 grams
1–5 years	23.0 grams
6–10 years	26.0 grams
11–15 years	37.5 grams
16–20 years	25.5 grams

After 20 years gradual atrophy.

Delafield and Prudden

At birth	13 grams
1–5 years	23 grams
5–10 years	37 grams
10–20 years	25 grams

By some observers relatively large roentgen thymus shadows in infants are considered usual. My observation of many young children has not convinced me that the thymus is proportionately large in infants. I am making this statement only from the roentgen viewpoint.

Studies of thymic function have been based principally on extirpation experiments following the work of Restilli in 1845. Feeding experiments have been conducted by others, and the morphology of the gland has been observed under various pathological conditions; for instance, the gland will atrophy in acute diseases. Therefore autopsies performed upon persons who have met a sudden death are most reliable. Dustin has shown from autopsies upon soldiers who have died suddenly that the gland is rarely atrophic. The theory that extirpation causes rickets has been shown to be false; also the statement that excision exerts a deleterious effect on skeletal development, genital growth, and physical maturity. The gland has been said to affect skeletal growth. This statement may be questioned since the skeleton grows not only when the thymus is large but also when it is undergoing atropic changes between the fourteenth and eighteenth years. Park and McClure after 75 controlled experiments with thymectomy on animals came to the conclusion that the thymus is not essential to life and that its extirpation produces no detectable alteration in the animal used for experiments.

In a review of 24 articles appearing from 1904 to 1924, Short of the Harvard Medical School stated conclusions cited by Mosher as follows:

1. The thymus is not necessary to life.
2. Thymectomy has no effect on the growth and development of the skeleton and organs.
3. Castration delays the involution of the thymus.
4. Thymus feeding to salamander larvae with parathyroids causes tetany.
5. A substance contained in the thymus when injected causes convulsions.
6. Thymic hyperplasia follows double suprarenalectomy.
7. Thymic hyperplasia in thyrotoxicosis is secondary.
8. In birds a relationship exists between the thymus and the egg producing mechanism.
9. So-called "thymic death" is not due to tracheostenosis and probably bears no relation to the state of the thymus gland.
10. One, if not the primary function of the thymus is to produce leucocytes.
11. The thymus may also have an antitoxic function (Hammar).

The evidence on the whole is strong that the thymus is not a gland of internal secretion. That it may serve as a manufactory and storehouse for lymphocytes at the time of life when there is the greatest need to combat infection seems to be a popular view. A preponderance of nuclein in the structure indicates that from this source may be derived a substance which modifies metabolism and which may reinforce immunity. Persistence of the thymus to an abnormal degree is noted in exophthalmic goiter in about three-fourths of the cases, the thymic enlargement being possibly compensatory. In Addison's disease, acromegaly, myasthenia gravis and rickets, persistence of the thymus has frequently been noted.

The association of sudden death with thymic enlargement was reported by Morgagni two hundred and fifty years ago and by Bichat in the eighteenth century. Kopp described thymic asthma early in the nineteenth century and Lee in 1842 referred to sudden death due to laryngeal spasm and asthma in children.

In 1858 Friedleben denied the possibility of production of laryngospasm by enlarged thymus and thereafter the controversy began, numerous authorities insisting that the symptoms emphasized by Kopp were due to direct mechanical pressure of the enlarged gland while others insisted that an excess of thymic secretion caused the trouble. In 1889 Paltauf's studies established the association of enlarged thymus

with a general lymphoid hyperplasia, arterial hypoplasia, and in older patients chlorosis. This condition became known as status lymphaticus.

The clinical picture of thymic hypertrophy is so often observed and described that one need only recall that:

(*a*) Thymic stridor may be manifest at birth and show varying degrees of intensity with intervals during which it is not in evidence, the paroxysms occurring as breath holding and so-called "rage spasm" or as asthma.

(*b*) Dyspnea may be constant and persistent.

(*c*) Sudden death with lymphatism demonstrable only at autopsy may occur without previous warning.

(*d*) Convulsions simulating tetany may constitute the only key to the condition.

(*e*) Even with marked thymic enlargement no unusual symptoms may occur.

(*f*) Thymic symptoms may be confused with those of congenital heart without murmurs or both may be combined, i.e., congenital heart and enlarged thymus.

In the latter types of cases the roentgen ray is the best method of differentiation. This point was first brought out by the writer in 1923, at which time he also emphasized the presence of a general secondary fibrosis of the lungs in children with chronic cardiac disease (Hartshorn and Perkins).

Susceptibility to sudden death, abnormal diminished resistance to infection and psychic instability are characteristic of thymic subjects.

The oldest and most popular theory to explain the sudden death of such individuals was that of mechanical pressure resulting from enlarged glands. While this explanation is believed by many to be unscientific it does explain, we think, the cause of sudden death in some of the cases.

Crotti notes that pressure may take place at two points; one at the superior opening of the thorax, into which the thymus is drawn on hyperextension of the head in coughing. This mechanism is brought about by the ligament attached to the thymus extending to the thyroid, the anteroposterior opening at the episternal notch in young subjects being not over 2–3 cm. The other point at which pressure may occur is between the innominate, the left common carotid, and the arch of the aorta. Another theory was based on the arterial hypoplasia which was supposed to permit cerebral hemorrhage under slight strain. This view has proved unsatisfactory. The theory that the thymus elaborated a toxin of some sort which under certain predisposing "shock states" produced collapse has likewise been proved unfounded.

Symmers' ingenious theory of anaphylaxis to account for these cases has been current for the past ten years, but as the result of sensitization experiments it has lost much of its early support. This theory holds that necrosis occurs in large numbers of germinal follicles in the lymph nodes with resulting sensitization of the body by specific nucleoprotein thus formed. When at a suitable period the tissues are again subjected to the action of the same protein derived from the nuclear dust formed in the same type of tissue the anaphylactic action is complete. Pappenheimer's emphasis on disintegration of nuclear material as evidenced by the thymus probably has contributed to the foundation of Symmers' ideas.

Yokoyama in 1913 showed that injections of extract of the thymus were hypotonic and lessened the action of adrenalin on the blood pressure.

Tracy has laid emphasis on the superabundance in the blood stream of thymic hormone, with insufficiency of the adrenals. Mosher has commented upon the similarity between death from acidosis and that from status lymphaticus.

Very recently MacLean and Sullivan have observed at the Babies' Hospital in New York a pronounced hypoglycemia with suprarenal insufficiency in three fatal cases of thymic convulsions in infants. The collapse seen in these cases is not unlike that seen in insulin shock.

Disturbed chemistry dependent upon endocrine imbalance certainly offers an explanation more plausible than others for the collapse observed in thymic cases. Just as the metabolic disturbances from goiter may be disproportionate to the size of the thyroid (although a large thyroid most commonly excites suspicion of true

hyperthyroidism) so hyperactivity of the thymus predicated upon the theory of a secretory function, might exist independently of acute anatomic thymus enlargement.

Reuben and Fox "feel that sufficient evidence has not been adduced to prove (1) that the thymus is the cause of the so-called thymic syndrome; (2) that the syndrome is due to hyperplasia or enlargement of the gland; (3) that there is an absolute correspondence between actual size of the gland and x-ray picture of it."

Recently Rubin has described 13 cases of pylorospasm with vomiting and suspected pyloric stenosis in children under two and a half months with thymic enlargement proven by roentgen examination. More than half the patients had symptoms suggestive of thymic enlargement; 5 of the cases were treated by roentgen therapy and all showed improvement.

Evans' investigations in 1924 show that the persistence of the thymus gland as a relatively normal condition has been demonstrated, although a positive roentgen finding is not always in evidence, but cessation of the symptoms are frequently noted after roentgen treatment. Many sudden deaths of children formerly thought to be due to bronchopneumonia, congenital anomaly of the heart or acute indigestion, in which autopsies have given little information as to the cause of death, may have been due to unrecognized thymic hypertrophy. Cases have been recently examined considering the possibility of thymic enlargement, in spite of possible negative roentgen findings, treated as such with the roentgen ray with satisfactory results and the disappearance of the thymic syndrome such as cyanosis and dyspnea.

From reports with such divergent views as illustrated in the previous extracts it is rather difficult for the clinician to derive much practical information. It is readily apparent, however, that three conditions require differentiation to which the following descriptive terms are applied: Thymic enlargement without involvement of the lymphatic system; status lymphaticus, without thymic enlargement; status thymicolymphaticus. It is essential to remember that the dyspnea of tracheostenosis is mechanically possible from thymic pressure and that without enlargement a child may exhibit the condition of a general adenopathy described by Paltauf, with arterial hypoplasia and diminished resistance to infection, anoxemia and trauma.

If it were possible for one to investigate every case of sudden death in adults unexplained by known lesions and those in children, especially including those in the first weeks of life ascribed to atelectasis and congenital heart disease without murmur, every death in infancy due to unexplained convulsions and bronchopneumonia, and every sudden death following the administration of antitoxin, anesthesia, trauma, and minor surgery such as thoracentesis, the result would be highly illuminating, and the conception and frequency of this complex which we are discussing would be put on a sound basis.

The collective investigation of status lymphaticus now being conducted in the British Isles will undoubtedly go far toward clearing up the situation. Symmers' report of 5,652 autopsies at Bellevue is very pertinent at this time; he states that findings of status lymphaticus were present in 457, or 8 per cent. Of the 457 only 92 were under twenty-nine years of age.

Although enlargement of the thymus may exist without status lymphaticus or any observed clinical disturbance, nevertheless hyperplasia of the tissue of the thymus, as a rule, constitutes the key to the general pathological condition. In 118 cases of status lymphaticus as reported by Symmers, the thymus was hyperplastic in every instance.

Whether or not a child presents clinical symptoms of status lymphaticus, enlargement of the thymus should be considered as evidence favoring the diagnosis of the above state, and whatever be the rôle of the enlarged thymus, the finding of an enlarged shadow in the mediastinum characteristic of the disease in its size, shape and outline and which is not interpreted as some other lesion than the thymus, with or without the thymic syndrome should be a warning as a potential danger when a

surgical operative procedure is being considered, irrespective of whether it is a major or a minor operation.

This introduces our practical problem, the interpretation of the roentgenogram of the thymus and its grave importance in prevention of mortality, especially when an operation is considered.

One is immediately confronted with a mass of semi-conflicting literature on roentgen technique and interpretation of what is an enlarged thymic gland. Among the writers who have expressed their opinions on this subject are Freeman, Quimby and Quimby, Pfahler, Gaarde, Grier, Friedlander, Drea, DeBuys and Samuel, Gerstenberger, Benjamin and Goett, Blackfan and Little, Benjamin and Lange, Liss and myself.

In the technique of examination it is well to keep in mind the following points: Exposures should be made in the erect posture, if possible, and at 6 feet. They should be short and on the expiratory impulse. Typical variations in shape must be considered such as slenderness of shadow, thickness and broadness, together with anomalies of position and relation. Mosher, MacMillan and Motley considered that any shadow at the base of the heart broader than one-half the size of the heart in the same patient is an enlarged thymus. They also stated that at autopsy, the shape and size of the thymus is not its true shape and size as seen in the roentgenogram; this is due to changes produced on its contour by the inflated lung, therefore the film should be taken on expiration in order to produce as nearly as possible its natural size and form. The thymus may be cervical, cervicothoracic, or thoracic, the last position being most common. The position varies with inspiration and expiration and to some extent with diastole and systole. In ordinary roentgenograms of the chest a shadow beneath the sternum represents great vessels and mediastinal glands. If there is a wide shadow, then enlarged bronchial glands, enlarged thymus, or anomaly of the great vessels are to be considered. If the thymus is long and narrow, but thick and large, an anteroposterior view might be negative. The thymic shadow is, however, distinctive and for practical purposes a bulging shadow at the base of the heart wider than the sternum and parallel to it, excluding any anomaly of the great vessels and enlargement of the mediastinal glands, should be considered as an enlarged thymus gland. Liss, in 42 per cent of a group of 119 newborn infants, found a shadow suggesting a thymus measuring more than 3 cm., and this without gross symptoms. Peterson and Miller state that abnormally enlarged thymus occurs in 40 to 50 per cent of newborn infants. Greenthal, after an analysis of 2000 consecutive cases ranging from three days to twelve years of age, admitted to the University of Michigan Hospital, reports thymic enlargement in 90, or 4.5 per cent. Eighty-seven gave no history of symptoms.

Mosher, MacMillan and Motley in a series of nearly 5000 consecutive roentgen examinations of children from two to sixteen years (tonsil and adenoid age) found 7 per cent to have an enlarged thymus.

During the summers of 1923–1926 a tonsil and adenoid operative service was maintained and is still functioning at the Seaside Hospital of St. John's Guild, New York. In those four seasons Dr. Floyd McDaniel has operated on 2000 patients with enlarged tonsils and adenoids. A loss of one patient early in the series whose thymus at autopsy weighed 54 grams, prompted Dr. R. G. Freeman in 1924 to advise preliminary roentgen examination of all cases before operation in order to recognize if possible any patients with thymic enlargement. The Hospital has already acquired a large collection of chest roentgen films of children which may be presumed to be fairly normal. There is also a cardiac service where numbers of cardiac and pulmonary films are available for study.

In 1924 the occurrence of the death, during anesthesia, of a little colored girl undergoing an orthopedic operation whose preliminary chest roentgen examination did not show a thymic enlargement before operation on account of its low position over the heart, re-awakened interest in enlarged shadows in the mediastinum above the heart. The writer in the year 1924 reviewed 237 cases of children and

found 10 with thymic enlargement and 8 other suspicious cases. Subsequently in 1925 the author reviewed 500 tonsil and adenoid patients whose ages were from birth to twelve years with a general average of six years; 25 definite cases of thymic enlargement were found and an equal number of suspicious cases were observed. The positive cases were not operated upon but those who remained in the hospital were treated by roentgen rays, with satisfactory results.

In the Fall of 1925 I had my attention called to the death of a patient in a hospital in New York where a preliminary roentgen examination had not been made. The child was operated upon for adenoids and tonsils and died suddenly in primary anesthesia. The thymus weighed 35 gm. at autopsy, the report diagnosed the condition as "status lymphaticus." The child was four years old, anemic but no previous history of cyanosis or convulsions was obtained before the operation.

In the summer of 1926 the writer in conjunction with Dr. G. F. Graves reviewed 700 chest films at the Seaside Hospital. When three observers agreed that the large shadow at the base of the heart was probably due to actual thymic hypertrophy the patient was so rated. When only two agreed the case was listed as doubtful. All films were taken in the posteroanterior position. If the objection should be raised that no measurements served as a guide in the estimation the answer may be made that the two groups, first, one of doubtful cases, second, one of fairly definite cases, did at least constitute a collection from the series representing distinct departures from ordinary roentgen findings. The estimates gleaned are rather conservative, in a way, as compared to reports from other sources. In this series of 700 films of children between one and seven years of age, 30 were rated as showing definite thymic enlargement, and an equal number as showing suspicious enlargement. In the latter group the orthopedic patient whose roentgen film was negatively interpreted, but whose thymus at autopsy weighed 39 grams, was included.

On the supposition that infants would show a higher rate of enlarged thymus than older children, as reported by observers elsewhere, a review of a small series of 28 roentgen examinations of the chest was made at the Seaside Hospital, all were infants under one year and 70 per cent were under six months. Three of this series, or 10.7 per cent, were rated as showing suspicious enlargement. The cases were taken at random from the ward and several were acutely ill as the weight of infants averaged 3 pounds below normal.

In a review of the histories belonging to the positive thymus cases it was possible to arrive at a few significant facts. Five had an operation under anesthesia without ill effect. One of the five had had roentgen treatment preceding operation. In one case, history of convulsions, dyspnea and other thymic symptoms was determined; one child had received 2500 units of diptheria antitoxin without ill effect. In a group of 18 in which the complete history was available, 6 had rickets, 2 had pneumonia, 12 had enlarged tonsils. General lymphadenopathy was in no instance noted. The cases were equally divided between males and females. The age limits were thirteen months and seven years in the positive group beyond one year of age, the average in the older group being one year and five months. In any case awaiting tonsillectomy or other surgical operation, when there was roentgen evidence of enlargement, operation was cancelled and roentgen therapy was instituted for the purpose of reducing the gland. When the gland was reduced operation was performed.

The observations at the Seaside Hospital thus indicate that between the ages of one and seven years 8.6 per cent of all the children show mediastinal shadows characteristic of thymic enlargement, and 4.2 per cent show a shadow larger than normal which warrants suspicion of thymic enlargement.

Therefore, a preliminary roentgen examination of chests in children in order to find possible thymic enlargement is in the field of prophylactic medicine and should be done when possible at all times. If in a thousand operative cases in children, 50 show definite roentgen evidence of thymic

hypertrophy, there is always the chance of postponement of operation, and the institution of roentgen therapy will probably save some lives. According to other observers and reports 50 cases of thymic enlargement in 1000 cases is a conservative figure. Some of these cases may be status lymphaticus, but there is very little difference as to the question of a possible fatality as the result of shock, either surgical or otherwise. A thymic death is a surgical tragedy and anything that can be done to avert such an outcome should be done immediately and not questioned. I have good reason to believe that there will soon be a demand for a roentgen examination of a child's chest prior to operation and if this is neglected, the physician or surgeon will be held responsible as is now the case in fractures. Into the difficulties of universal preoperative roentgen examination of the thymus as a measure of safety in pediatric surgery, one need not go. The practicability of this step has been I believe proven in many instances. The added advantage of heart and lung examination is without question. It has always followed that when something could be done for the better protection of the patient, it would in the end be demanded and thereby become routine.

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OBSERVATIONS ON EIGHT YEARS' EXPERIENCE IN THE TREATMENT OF THE THYMUS GLAND IN INFANTS AND YOUNG CHILDREN*

BY MILA J. KINNEY, M.D., AND RAYMOND G. TAYLOR, M.D.

From the Roentgen Laboratory, Hospital of the Good Samaritan

LOS ANGELES, CALIFORNIA

OUR interest in the size, symptoms, and treatment of the thymus gland was first aroused in October, 1920, by the following case:

A well-developed male infant began to have attacks of cyanosis, dyspnea, stridor and choking when nursing. The mother became much alarmed because three other children had died with similar symptoms. A pediatrist was called in consultation, and he suggested the possibility of the thymus gland as the cause. A roentgenogram showed an upper mediastinal shadow 6 cm. wide at the level of the third dorsal vertebra. A roentgen treatment was given at once over the upper anterior chest with the following factors: 5 ma., 8 in. spark gap, 8 in. skin target distance, 3 mm. aluminum and 4 mm. leather as filters; time, 3 min. There was a rapid and definite improvement in the symptoms. Six days later the shadow had diminished to 4 cm. Another treatment was given with the same technique, except that the time was lengthened to five minutes. Five weeks later the shadow had increased a little in width but there was no return of symptoms. Nevertheless, treatment was given to both the anterior and posterior chest; time, four minutes each with the other factors as above. At three and one-half years of age he was a well-nourished, normal boy with an upper mediastinal shadow 1 cm. smaller than at the last examination or when about two months old. He had had no symptoms and was only returned by request for a check-up roentgenogram.

This was such a spectacular case that the obstetricians became much interested and began to request roentgen examinations of many cases, often those without symptoms.

A series of 160 infants was then studied within the first twenty-four hours after birth. These were all of well-to-do parents who were private patients. We concluded, as has Bliss,[5] that there is no normal thymus as to size, shape, or density, nor was there any constant relation to the weight or sex of the child. Evans[19] decided after post-mortem studies that the shadow of the normal gland could not be differentiated from that of the spine. Liss,[42] after roentgenographing 119 newborn infants, called a shadow of less than 3 cm. that of a small thymus and over 3 cm. large. This latter included 42 per cent of his cases. Macneill[44] and McKinney[46] each found 40 to 50 per cent of their infants examined to have so-called thymic enlargement. Mulherin, Holmes and Harrell[50] concluded from their study of 111 cases of newborn that 2.96 cm. was the average width of the thymus shadow, measured at the second intercostal space. In our series of 160 cases, there were 54 with a shadow less than 3 cm. wide; 36 with a shadow 3 cm. wide, and 70 with a shadow over 3 cm. wide. These were measured at the level of the third dorsal vertebra. Mulherin, Holmes and Harrell concluded also, that the position of the diaphragm made no material difference in the inter-

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pretation of the shadow in diagnosis. Gerstenberger,[26] on the other hand, thinks the position of the diaphragm is largely responsible for the difference in the width of the shadow in roentgenograms made at the end of expiration and of inspiration. It seemed impracticable to attempt roentgenography in any definite phase of respiration in such young infants. In those older, we have repeatedly found the shadow wider in a film made at the end of expiration than in one made in full inspiration with only time intervening to adjust the second film. Neither were the infants in our series uniformly sleeping or crying. Pfahler[59] states that the gland enlarges when the child cries, but Mosher, MacMillan and Motley[49] concluded from their series that crying did not materially increase the gland shadow. The majority of the infants in our series were again roentgenographed before leaving the hospital; that is, at two to three weeks of age for comparison of the shadow. The number showing a shadow of approximately the same width was about equal to those showing an increase of 0.5 to 1 cm. Those showing a decrease was about one-half as many as in either of the above groups.

We are at present using practically the same technique as we have followed from the beginning. The roentgenograms are made with double screens at 30 in. film target distance, $\frac{1}{10}$ of a second time, and centered over the sternum at the level of the second rib. All are taken with the child supine. We have not used the erect and prone positions of Remer and Belden[60] enough to determine any advantage over the supine. It has been found easier to keep the patient, whether infant or child, more nearly relaxed and quiet when lying on its back. Theoretically, the resulting shadow may be slightly distorted and enlarged but practically little difference has been noted; not enough in our opinion to warrant the increased difficulties in technique. We have not made the lateral roentgenogram advocated by Chamberlain[10] sufficiently often for it to have a definite diagnostic value in each case. In several we thought there was some narrowing or displacement of the trachea but have not yet satisfactorily demonstrated a change in its relative position. We are planning to gain more experience on this point. Gerstenberger[26] and others believe that the roentgenoscopic examination is valuable in determining changes in size during respiration, but Peterson and Miller[58] think that stereoscopic films taken at the end of expiration are of more practical value. These we have never attempted.

We have found no fixed relation between the symptoms, and the size, shape, or density of the thymus. A shadow 3 cm. wide might exhibit alarming clinical manifestations, whereas one 4 to 5 cm. wide and equally dense as far as could be judged from the roentgenogram, would be silent. This fact has been one of the reasons why some have advanced the theory of disordered internal secretion, but as Morse[48] says, "If there is such a secretion, no one knows what it does and consequently no one knows what would happen if there was a change in the amount of secretion." Bliss[5] suggests the term "symptom producing thymus" as preferable to the commonly used one of enlarged or hypertrophied thymus. Noback[52] believes that symptoms pointing to the thymus gland call for treatment regardless of the size.

Up to February, 1928, we have treated 213 cases, most of whom were not referred to us until after one or more capable pediatrists had considered the various conditions such as are enumerated by Friedman[25] as necessary when making a differential diagnosis, and after other methods of treatment such as suggested by Wasson[68] for stridor had been tried without relief. This largely accounts for our favorable results which correspond with those of Morgan, Rolph and Brown[47] who report 96 per cent of their cases as relieved of symptoms by treatment. Two infants in our series died before the second treatment could be given. An autopsy was obtained on one, dying ten hours after birth, and the pathologist found a large thymus of the pedunculated type with nuclei already showing the effect of irradiation. Two other infants, several months old, and weighing about the same as at birth, died after one treatment, although in one, the symptoms of dyspnea

and cyanosis were much improved for several days. Four children were not returned for subsequent therapy for one cause or another; in one case, friends frightening the mother with tales of roentgen burns.

At first we used a dose of 25 ma-min., 8 in. spark gap, 8 in. skin target distance, 3 mm. aluminum filter, 4 mm. leather, over two areas, one anterior and one posterior, over the upper mediastinal region. The child was returned in three weeks when a check-up roentgenogram was made, and if the shadow had not diminished satisfactorily, or if part or all of the symptoms continued, another treatment was given. Occasionally a baby would have a reaction, such as refusing to nurse, vomiting, some rise in temperature and restlessness, or more rarely a tendency to stupor. Because of this we decided to use 30 ma-min., 9 in. spark gap, 6 mm. aluminum and 4 mm. leather filter over one area only, and repeat in a week, alternating the anterior and posterior chest. With our equipment, this was equivalent to one-half a skin erythema dose. We are still following this plan. Rarely we find that an infant reacts unpleasantly to this, and then we use 15 to 20 ma-min., repeating twice weekly. In the majority of cases four 30 ma-min. doses, that is, a total of 120 ma-min., or the equivalent in smaller doses, is sufficient to reduce the gland shadow to about the width of the dorsal vertebra.

In young infants an improvement in the symptoms has often been noticed in ten to twenty-four hours. In several instances it has been necessary to administer oxygen almost continuously, even during the first treatment, but the dyspnea and cyanosis have shown such a definite response to therapy that the oxygen could be omitted before many hours. Evans[18] and Friedlander[24] have also seen early relief following treatment. With regard to the early relief before the gland could diminish sufficiently, which has been attributed by some to change in secretion, Wasson[68] suggests this as being due to the effect on the mucous membrane of the trachea and adjacent bronchi, since he has often found the respiratory tract also involved. As early as 1914, Cozzolino[11] observed that roentgen therapy exerted a similtaneously favorable effect on tuberculous tracheobronchial adenopathy, which exists often with thymus enlargement. Grier[30] says he has never seen any relief from one roentgen dose, and prefers radium as do also Barbour and Goin,[3] Pfahler[59] and others, because of results obtained and ease of application.

The maintaining of the child in position and keeping it sufficiently still and protected during the roentgen treatment has presented no great difficulty in our laboratory. All children, whether infants or even ten or twelve years of age, are prepared in the same way. Two pillows are placed on a stretcher, one for the head and the other lengthwise in the shape of a letter T. A turkish bath towel is laid across the second pillow with the ends hanging over the sides of the stretcher and the child is placed with its shoulders and upper trunk on this towel. The ends are then brought over the shoulders and arms which have been extended along the side of the chest, and securely pinned to the pillow with large safety pins placed between the arms and the body, the first well up toward the axilla, one about the level of the elbow and the other near the wrist. Two more bath towels (one is sufficient for an infant) are laid across the body and legs and pinned on each side to the mattress covering the stretcher. This allows the child to move its hands and feet and yet prevents it from turning or rising up. The protection for the face and thyroid is made of a strip of lead ⅛ in. thick, 18 in. long, and 12 in. wide, bent in the form of an inverted U. Across one side has been fastened another piece of lead which hangs down about half way as would a curtain. This hood-like protector is placed over the face, the ends resting on the pillow at each side of the head, or on sand bags in the case of older children. The curtain-like piece of lead extends to the anterior chest wall at the level of the clavicles, thus including the neck with the thyroid and parathyroids under the lead hood. A folded face towel is laid across the upper chest and neck so the protector does not touch the skin. The head can

be turned from side to side without disturbing the protection. A strip of lead impregnated rubber cloth 14 in. wide is laid across the child's lower chest and abdomen and pinned at the four corners to the mattress.

There were 148 boys and 65 girls in our treatment series. Among the 44 children presenting no symptoms but with definite upper mediastinal shadows discovered and treated preliminary to surgery, the proportion of boys to girls was three to one. In 10 instances, there were two children from the same family, one pair of twins being included. There were three other sets of twins, only one of each pair needing therapy. Four of the babies treated were from families where other children had died with similar symptoms, the cause of which had been unrecognized.

According to the findings of Greenthal,[29] a large percentage of children with congenital malformation defects also have enlarged thymus. There was only one child with club feet and one with cleft palate referred to us. Neither of these presented any symptoms, and the thymus was only discovered during the preoperative examination.

Three of the newborn infants with atelectasis had also enlarged thymus glands which were treated. Evans[19] observed that "in all cases of unilateral atelectasis the lobe of the thymus on the affected side showed the greater enlargement," and concluded that this might "be a factor in the failure of the lung to be properly aerated." The question has been raised in our minds whether this appearance might not be due to the fact that the unaffected lung is emphysematous and as a result the mediastinal contents have been crowded over to the affected side, since it is a well-known fact that the mediastinal contents are very movable in infants and young children.

Torrey,[65] Graves and Perkins,[28] and others mention convulsions as a symptom which should direct attention to the thymus gland. Reuben and Fox[61] think that all children with convulsions, even when typically epileptic, should be given therapy over the mediastinum, since in their experience some cases have been relieved even though the thymus enlargement could not be demonstrated. With this in mind and at the request of the attending physician, four of the usual therapeutic doses were given a six year old boy with a small thymus shadow, but no definite improvement was noted. The only other case which has come under our observation was that of an eight months' old child who had always been well but suddenly developed severe and frequent convulsions. A well-known pediatrist was called who eliminated all the usual causes. In spite of treatment there was no relief and as a last resort the child's chest was roentgenographed for enlarged thymus even though the physical signs were negative, and the therapeutic dose was given. There were only three mild seizures in the eleven hours following, and none thereafter. One more dose was administered the next day and a roentgenogram made two weeks later showed a disappearance of the thymus shadow, and so far as we have learned this child has remained well.

Repeatedly one reads that congenital heart disease must be differentiated from enlarged thymus gland. That this is not always easy to do is demonstrated by the following cases:

CASE 1. (No. 13275.) L., girl. This case was referred to us after having been diagnosed by a roentgenologist of wide experience as a congenital heart. She was three months old and presented symptoms of attacks of rapid pulse, pallor and lifelessness. A roentgenogram showed a shadow 5 cm. wide at the level of the third dorsal vertebra, extending upward from that of the heart and of equal density. This was interpreted as that of an enlarged thymus gland and was treated. Ten days after therapy had been commenced the shadow had diminished to 2.5 cm. in width, and the symptoms were markedly improved. Following four treatments there was a further reduction in the width of the gland, together with the disappearance of symptoms and a gain in weight. Nothing unusual was noted in the cardiac shadow after the thymus shadow had disappeared. Roentgenograms made two weeks later revealed no change, but those made six and twelve weeks after completion of the therapy demonstrated an increase in the upper mediastinal shadow to about its original width but without return of symptoms, and no further treatment was given.

Case II. (No. 15915.) C., boy, newborn, was sent to the laboratory with a clinical diagnosis of hypertrophied thymus and symptoms of choking, rapid and irregular respiration, attacks of pallor with limpness. A roentgenogram showed a dense thymus shadow 5 cm. wide, and a therapeutic dose was given during which it was necessary to administer oxygen. Three weeks later and after a total dosage of 75 ma-min. the shadow at the level of the third dorsal vertebra measured 3 cm. but was 4.5 cm. wide at the clavicles. Two more treatments were given. At this time the heart shadow had definitely increased, extending 2 cm. to the right of the midline and almost to the lateral chest wall on the left. After another interval of three weeks the thymus shadow had diminished to 3.5 cm. at the clavicles but remained the same at the lower level. Although it now seemed clear that this was a case of congenital heart disease, the pediatrist requested further treatment because of the persistence of the thymus shadow and a seemingly slight improvement in the symptoms following therapy. The anterior and posterior chests were each given 30 ma-min. Two months later the roentgenogram showed some increase in the size of the gland which was again diminished in width and density by a few treatments. The cardiac shadow showed a marked increase in size when compared with the first roentgenogram made, and the child eventually died at the age of six and a half months.

That such an increase in the cardiac shadow is not normal is apparent from the statement of DeBuys and Samuel[15] who concluded after 450 observations on children from birth to one year of age, that the growth of the heart is proportionately slower than that of the thorax, and Scammon[62] also says that most of the external dimensions of the chest increase between 30 to 50 per cent in the first year of postnatal life but that the heart as a whole grows relatively little in the first year. When there is a question of the case being that of a congenital heart alone or in combination with a large thymus gland, it would seem advisable to give a therapeutic test of a few doses of roentgen rays. These would reduce the thymus gland if present, eliminating this source of symptoms, and would more definitely reveal the true size of the cardiac shadow.

No standard has been reached as to how long to continue the treatment of the enlarged gland. Many, among them Hess,[34] believe that the relief of symptoms and not the reduction of the size of the gland shadow should be the guide. Freeman[21] advocated treating until the gland had disappeared without regard to cessation of symptoms, and mentioned a case in which the symptoms had returned after incomplete treatment. Lange[41] as early as 1913 says that recurrences due to regeneration in the gland are to be watched for and controlled by further treatment. Morgan, Rolph and Brown[47] state that the symptoms were relieved in 96 per cent of their cases but that 20 per cent had recurrences which responded to further treatment. They are now giving at least one treatment more than seems immediately necessary so as to avoid a repetition. In the majority of cases we have continued the therapy until the shadow has decidedly diminished or disappeared.

In our series of 213 cases, there were 7 in whom the thymus was later found to be about as large as before treatment but was unaccompanied by symptoms. In 3 of these, therapy again reduced the size of the gland preliminary to tonsillectomy. There were 12 boys and one girl who had a return of both symptoms and gland shadow with a disappearance of both after the second course of treatment. Two other boys with large thymus shadows and thymic symptoms were treated with a simultaneous disappearance of the shadow and symptoms, and subsequent return of both with again simultaneous disappearance of the shadow and symptoms on treatment, and after an interval of several months, the symptoms and shadow again returned, and for the third time disappeared following treatment.

Case III. (No. 14978.) G., boy, was referred when two months old because of noisy respiration and attacks of cyanosis. Four 30 ma-min. doses were given and both symptoms and shadow disappeared. Two and one-half months later the symptoms and gland shadow returned and a similar dose of roentgen radiation was administered, with the same result as before. After six months the symptoms mentioned above returned. A roentgenogram showed that the gland had also enlarged, and

for the third time treatment was followed by relief.

Case iv. (No. 12921.) B., boy, three years of age, was referred to us after having been carefully studied by several pediatrists and all the usual causes for presenting symptoms had been eliminated. There was loss of appetite and weight, nervousness, restlessness especially at night, cough and hoarseness at times, also pallor and violent attacks of temper. Roentgenograms showed a thymus gland of the columnar type, moderately dense, and 4 cm. wide at the level of the third dorsal vertebra. This case came to us on December 30, 1924. He was treated over six areas, 30 ma-min. each, between January 26 and March 6, 1925. After the first treatment, improvement was noted in the irritability, nervousness and hoarseness. His appetite had increased. Improvement was more marked after the third treatment and there was a decided thinning in the density of the gland. Roentgenograms made three and six months after the first treatment showed practically no gland density. Nine months after his first visit, or in September, 1925, he was again referred to us because of return of symptoms. The gland at this time was as large as before and more dense. The symptoms improved and the gland shadow practically disappeared following treatment. Roentgenograms made three and six months later showed no increase in the shadow nor was there a return of symptoms. The child was gaining in weight and height, and a decided improvement was noted in self-control. In November, 1926, symptoms of extreme nervousness, almost insane fits of temper, and attacks of extreme pallor were again manifested, and the thymus gland was found to be about the same density and width as in September, 1925. Four doses of 30 ma-min. each were given with a definite clearing up of the symptoms and shadow. Check-up roentgenograms at various times during 1926 and 1927, also in January and March, 1928, show no return of the gland and the child is apparently normal in every way.

It would seem as though there could be little doubt as to the cause of the symptoms and their relation to the upper mediastinal shadow in these 15 cases and particularly in the 2 in which therapy was administered three times with equally definite results.

SUMMARY

1. In a series of 160 consecutive infants roentgenographed within the first twenty-four hours after birth there was found no normal thymus shadow as to size, shape or density, nor any constant relation to the weight or sex of the child. The technique used in taking and measuring roentgenograms is stated.

2. In a series of 213 children given roentgen therapy, no fixed relation between the symptoms and the size, shape or density of the upper mediastinal shadow could be determined. A detailed method of immobilizing and protecting the patient is related; also the therapeutic dosage employed.

3. The enlarged thymus in combination with atelectasis is referred to, also a case is cited in which convulsions were the only symptom. The difficulty of always differentiating between enlarged thymus and congenital heart is illustrated by two cases.

4. Of the 213 patients treated, 7 had a return of the gland shadow unaccompanied by return of symptoms. Twelve boys and one girl had a return of both gland shadow and symptoms, with the disappearance of both after a repetition of the therapy. Two other boys demonstrated the phenomena of the simultaneous appearance of the symptoms with the upper mediastinal shadow and the simultaneous disappearance of both after appropriate treatment on two separate occasions subsequent to the primary disappearance.

5. It seems logical to conclude that in some cases there is a definite relationship between the size of the gland and the symptoms manifested. That the symptoms are not due alone to pressure is very strongly suggested by cases in which the upper mediastinal shadow after reduction by therapy enlarges to its original size but is unaccompanied by the former symptoms.

6. From our observations we have been led to believe that in the newborn, attacks of cyanosis with or without dyspnea, or rarely attacks of extreme pallor with flaccidity are more often associated with enlarged thymus or atelectasis than with all the other causes combined and that in the majority of cases the offender is the thymus gland.

7. We have always attributed the very high percentage of our success in treatment

to the elimination process through which nearly all the children have passed before coming to our laboratory. Practically all the cases have been thoroughly studied by competent pediatrists before being referred for roentgen therapy.*

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* For discussion of this paper see page 276.

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THE ROENTGEN DIAGNOSIS AND TREATMENT OF ENLARGED SYMPTOMLESS THYMUS*

BY FREDERICK W. O'BRIEN, M.D.

BOSTON, MASSACHUSETTS

FOR some years now, it has been the routine in certain hospitals to examine all children roentgenologically before submitting them to a general anesthetic. If there is found what is thought to be an enlarged thymus gland, a prophylactic roentgen treatment is given, because of the rather well-entrenched belief that an enlarged thymus gland is an integral factor of the syndrome of so-called status lymphaticus, a reputed cause of otherwise unexplained sudden death.

An enlarged thymus as a symptom-producing organ, and the roentgenologist's ability to diagnose it, have not gone unchallenged. Status lymphaticus, indeed, as a pathologic entity is declared a misconception.

Hence the current practice of roentgenographing children to determine the size of the thymus with a view to radiation treatment before operative procedure may be potent of harm because of its medico-legal implications. If it becomes "common knowledge" in its juridical sense, as applied to the practice of medicine, then the practitioner or specialist who fails to utilize it may lay himself open to suit for malpractice.

If the routine of examining the mediastinum of infants and children is only a vagary of the roentgenologist, it should be abandoned. If it can only be defended on the law of possibility, the method should not be over-emphasized and its limitations should be made clear to the profession.

The subject, as I see it, resolves itself into two propositions:

1. Is there a symptom-producing enlarged thymus in infants that can be diagnosed by the roentgen ray and relieved by irradiation?

2. Is there an enlarged thymus without symptoms in infants, children and young adults, which represents objective evidence of status lymphaticus, and which can be diagnosed by the roentgen ray and should receive prophylactic irradiation?

Noback[5] has shown that the lobation of the thymus is determined early in fetal life, that the bilobed type of thymus predominates and that its location is most frequently cervicothoracic. The organ is distinctly broad in outline, extending laterally as far as the anterior axillary line in most cases and is practically never overlapped by fetal lungs. This distinctly broad type of thymus described as being the fetal type he also showed to be typical of fullterm stillborn children.

The thymus of infants in which respiration has been practically or wholly established is usually cervicothoracic in location, is elongated in form, and bears the impress of the organs with which it is in contact. The right lung extends, says Noback, on its anterior surface in every case, the left lung extends over its anterior surface in 4 out of 5 cases. The thymus overlaps the right ventricle of the heart on the right side in more than 50 per cent of the cases, and on the left side in more than three-fourths of these individuals.

The transition from the broad or fetal type to the elongated or molded type of thymus found in the individual who has breathed is accomplished during the time in which respiration is completely established. The expansion of the lung changes the position in relation to the thoracic contents and, along with the other organs and viscera of the thorax, the thymus is markedly affected. It is compressed both laterally and anteroposteriorly with the result of elongation and molding, and extension over the right ventricle.

Noback believes that in the neonatal period, the degree of expansion of the lungs is a more potent factor in determining the lateral extent of the thymus than the actual size of the organ and during this period, at least, the thymus, lying in the

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usually described normal area, may exert marked pressure on the structures posterior to it. This may be due either to an unusually large thymus, or to a very narrow superior thoracic aperture, which will not allow the thymus to protrude into the cervical region, as it is compressed by the expanding lung.

The thymus in late fetal life and in the newborn is related posteriorly to the pericardium over the base of the heart and great vessels. Noback says that it may extend in exceptional instances, as in one of his series, to the left vagus nerve. On the right it is generally found to be applied closely to the superior vena cava. The left innominate vein and occasionally the superior vena cava is embedded in the posterior aspect of the thymus. In a few cases, he found that these vessels actually ran through the substance of the gland. The innominate artery is closely applied to the trachea and crosses it diagonally and the left innominate vein passes across the artery at the level of the upper border of the sternum. An increase in the anteroposterior extent in the thymus in this region would, he says, due to the rigidity of the superior thoracic aperture, compress the above-named structures. In several of his cases this had evidently occurred.

The thymus is not a transitory organ, but exists and functions even until old age, according to Hammar,[3] a view which is very generally accepted. He shows that the turning point in the existence of this organ is the age of puberty (eleven to fifteen years). Up to this time, not only does the size of the organ itself increase, but what is the essential point, the parenchyma remains undiminished in total volume. After this time, on the other hand, there occurs a rapid reduction of the bulk of parenchyma in the organ, while at the same time the interstitial connective tissue usually assumes the character of adipose tissue, and forms a greater and greater part of the organ. It is only after the age of fifty-five among healthy persons who have met with a sudden death, he says, that we find occasional cases in which a division of the cortex and the medulla can no longer be established, while on the other hand in other individuals, it can be demonstrated under similar conditions up to seventy years of age.

Not only in man, but in various animals, has it been possible to establish that age involution of the thymus begins at sexual maturity. That the sexual glands really play a decisive part in the age involution of the thymus is best shown in the condition of the thymus after castration. In the castrated subject, a reduction in the parenchyma takes place, but slowly, which leads Hammar to conclude that by the side of the predominant influence which the sexual glands exert on the process of age involution, other factors at present unknown to us, are although to a less extent also operative. The chief cause of the diminution in volume of the cortex is the decrease in the number of lymphocytes.

Hammar says that the thymus is never found in normal condition in a subject who has died from disease. In such a case the parenchyma is generally reduced by accidental involution. Accidental reduction in the size and amount of parenchyma in the thymus, that is, accidental involution, is produced, he says, not only by the majority of diseases, but also by other sorts of influences—inanition, roentgen treatment and pregnancy.

Nothing definite is known about the function of the thymus. It has no secretion as such; that involution in otherwise normal children begins at puberty connotes a definite relationship to the sex glands.

Shellshear[7] in a series of autopsies on the Chinese found abnormally large thymus glands with an abundance of parenchyma in ages up to fifty in subjects showing delayed secondary sexual characteristics.

There has been much experimental evidence adduced in an attempt to link the function of the thymus with nutrition and growth, but Park and McClure[6] have ruled all this out as false evidence based on inexact experimental data. Referring to Basch's work on thymectomized puppies, they say: "It seems entirely possible to us that all the changes Basch reported, both clinical and pathological, could readily

have been the result of confinement alone or confinement in combination with poor feeding and disease."

Employing a rigid technique, in their experimental work, both in their method of performing thymectomy and in the care of their animals, in an attempt to reproduce the reported results of previous observers, Park and McClure concluded that the thymus gland is not essential to life in the dog; extirpation of the thymus produces no detectable alteration in the hair, teeth, contour of the body, muscular development, strength, activity or intelligence of the experimental animal. Extirpation of the thymus probably produces no alteration of the organs of internal secretion. It is possible that it produces well-marked changes in the organs of internal secretion during the period immediately following thymectomy, which was not covered by their experiments.

Friedleben, whose celebrated monograph on the thymus gland Park and McClure declare still remains the greatest single contribution to that subject, concluded that the thymus gland is not essential to life but that the thymus and spleen together are essential, that the death which follows the removal of both of these organs is one of wasting brought about by the failure in the positive blood formation, caused by the cessation of their combined activities. Nevertheless, he regarded the thymus as an important organ the functions of which were especially concerned with nutrition and growth. Because of his operative method, Park and McClure doubt that any of his thymectomies were complete, thus vitiating his conclusions.

Hammar's view of the function of the thymus, after twenty years of study of this organ, is that the lymphocytes in the thymus are necessary postulates for the function of the organ, but that the essential functional changes take place in the epithelial thymus reticulum, in the form of an enlargement of separate cells or cell-groups, causing in mammals the formation of the concentric cell complexes known as Hassall's corpuscles. These originate under the influence, direct or indirect, of the lymphocytes in the medullary reticulum, which is prepared and sensitized by special influences (the thyroid?) and they form the morphological expression of an antitoxic activity.

While no single appropriate function can as yet be attributed to the thymus, its functional interrelationship and importance to the organism as a whole is apparent.

It is known that a substance contained in the thymus when injected causes convulsions; thymus feeding to salamander larvae with parathyroid causes tetany, that in birds a relationship exists between the thymus and the egg producing mechanism, and that thymic hyperplasia is secondary to double suprarenalectomy, castration and thyrotoxicosis; occurs in Addison's disease, myasthenia, acromegaly, and is said to be present in cases of so-called thymic death. It is only with the latter that I am concerned here.

The normality of so-called persistent thymus, as first demonstrated by Hammar, has been confirmed roentgenographically by Wasson[8] and others, who observed enlargement of the thymic shadow to be the rule in well-nourished infants and children.

Boyd[2] more recently showed that the fluctuations in the weight of the thymus at any age are concomitant with fluctuations in body weight, and that the growth curve of the thymus in a well-nourished child is of the same type as that of the lymphoid tissue in general.

There is no absolute gravimetric evidence for or against status lymphaticus, since the weight of the normal thymus at any age is so variable that it is practically impossible to say in any individual case whether it is too large or too small (Bratton).

Two extremely important facts must not be lost sight of, namely, the relationship of the thymus anatomically to normal adjacent structures and its relative size to the mediastinum and thoracic cage as a whole (relative weight).

Cases of thymic death are readily referred to two distinct groups, those with and those without symptoms.

Accepting the concept of the evolution of the thymus, I do not find any student of the subject who does not concede the

existence of a symptom-producing thymus at least in infants. The groups with symptoms usually display the so-called syndrome of thymic asthma, characterized by attacks of inspiratory dyspnea, inspiratory stridor and the so-called Rehn's symptoms, the expiratory swelling of a tumor, the cranial thymus end in the jugulum.

Hammar states: "It seems to be proved quite conclusively that in certain cases of this kind it really is the thymus that produced the fatal symptoms by pressure on the air-passages." Boyd reconstructs the process this way: During the period in which the thymus in the newborn child is being compressed around and between the mediastinal structures, it is also losing weight. After this process is well under way or is complete, the gland begins to increase in size, so that the portions of the thymus around and between the blood vessels and the trachea may grow sufficiently to cause pressure on vessels and nerves, particularly on the recurrent laryngeal nerve. There are two clinical observations which support such a hypothesis: (1) most children do not develop thymic symptoms until from one month to six weeks of age; (2) these children frequently have along with an inspiratory stridor, hoarseness and a crowing cry suggestive of spasm of the vocal chords, of irritation of the recurrent laryngeal nerve. Blackfan and Little[1] noted that this cry sounds like the brassy voice of a man with an aortic aneurysm. Such a thymic death is surely to be considered as due to mechanical causes.

The other group of so-called thymic deaths occurring in older children in an apoplectiform manner without premonitory symptoms is the one responsible for the current hospital practice to which I have referred of roentgenographing all children before anesthesia.

The idea of an abnormally enlarged thymus in these cases of death is obviously due, Hammar believes, to a great extent to insufficient knowledge of normal conditions of size of the organ and a misleading comparison between those glands that have not as a rule undergone accidental involution and those that have undergone such involution. He says there is no support for the view that the *primary* cause of death is to be sought for in the thymus, although he cannot exclude the possibility that in such a thymic death there is present in the organism a state of increased vulnerability, which is reflected in the thymus by a less than average number of Hassell's corpuscles, but that in either case it is not reasonable to suppose that a reduction of the number of Hassell's corpuscles is the cause of death, but is only an expression of a state produced by other parts of the organism, possibly by other endocrine organs.

It has been suggested that these sudden deaths have been due to improper anesthetization and poor operative judgment and technique. But they occur even without anesthesia and following minor or no surgical procedure at all. These are the cases that are the tragedies of practice and if personal, or under one's immediate authority, cause one to pause.

Mosher, well aware of the newer concepts, clings to the old idea that the thymus is involved in these sudden deaths, and he has the added argument of no sudden death at his great clinic since his study with MacMillan and Motley.[4] They found out of a total of 2,344 children, a positive thymus shadow in 7.5 per cent. Of the positive cases treated by roentgen radiation all were successfully operated on and since employing the routine roentgen examination of the mediastinum, they have had no sudden unexplained death under anesthesia.

This has been the practice for two years at the Boston City Hospital and the Cambridge Municipal Hospital, with both of which institutions I am connected. At the Boston City Hospital out of a total of more than 2,000 children, there has been but one unexplained death under anesthesia, which occurred recently. There had been no prior roentgen examination and there was no autopsy. At the Cambridge Municipal Hospital, in 526 cases there have been no deaths. A survey of the chests showed a "broadened mediastinal shadow" in +6 per cent.

Disregarding for the moment enlarged thymus as objective evidence of disease,

it is argued that it is not possible to determine from a roentgenogram whether or not a thymus is larger than normal. Of course the answer here is the same as elsewhere. All that is necessary is to study a large enough group of well and sick by identical technique and plot the results.

Wasson has made the most adequate roentgen study of the thymus with which I am familiar. He studied a group of children by serial roentgenograms and serial physical examinations from birth to the age of three years. From roentgenological and necropsy study, he concluded that the two auricles and the great vessels form the base of the heart shadow; the aorta lies in the middle of the mediastinum and in the newborn infant is not seen as a distinct shadow because of its position. It passes directly up, turns directly back, and passes down behind the heart; it is only in later life that it forms the typical aortic arch seen in adults.

If then there is no sizable thymus present, the great vessels, the vena cava, aorta and pulmonary artery, form a shadow, triangular in shape, which quickly narrows as it passes upward toward the first rib, and at its narrowest point is less than the transverse diameter of the shadow of the spinal column. If the thymus is present in any considerable size, it will be found to overlap the base of the heart and pass upward obscuring the shadow just described of the great vessels. The shadow of this thymus is again triangular in shape, with its base overlapping the base of the heart, and especially the auricles. Its transverse diameter at its broadest point, which is usually the third interspace, may be two or three times the diameter of the shadow cast by the thoracic spine. This shadow of the thoracic spine is taken by measuring the diameter of the vertebral body. If the shadow of the thymus is no greater than that cast by the great vessels, it is a small thymus.

The position of the infant or child is a much debated point and it is a question whether the roentgenogram should be taken at inspiration or expiration. As Wasson says, it is likely that any one of these methods could be used in a routine manner. The roentgenologist should elect a method meeting his requirements and then make all roentgenograms under these conditions, so that his comparisons and deductions may be uniform.

Wasson selected the posteroanterior position, in the recumbent posture, at full inspiration, which I follow. He insists that these positions be exact, with no oblique views, unless for special conditions. The diaphragm must curve well downward from well beneath the heart, and its crest should maintain a uniform level on the thoracic spine, which is usually about the eighth vertebra, and is quite uniform in a series of roentgenograms on the same child. Under these conditions, the mediastinal viscera occupy the mediastinal spaces with ease, and neither produce unnatural bulging of the thymus or create a space into which the thymus may fall.

The mediastinal shadow under these conditions is about one and one-third times that of the bodies of the thoracic vertebrae, unless it is increased by the thymus or some pathological condition, when measured at the level of the second interspace. Wasson says, "The question must then be answered, 'Does this technique fully portray the thymus gland?'" and he replies, "I have had the opportunity of examining infants and children from birth to a few years of age, both before and after death with roentgen ray and checked with necropsy, and have found the anatomy as portrayed by the roentgenogram to be surprisingly accurate."

His conclusions are that in the infant under two years of age or so, the thymus is variable in size, not only in different types of infants, but in the same infant at different times. These thymuses may be classified as to size, and it is found fairly definitely that underweight infants have small thymuses, and those overweight have large thymuses. While the average weight infant usually has a moderate sized thymus, this does not adhere so strictly to the rules. There is an increase in the thymus from birth to one year of age, and it then reduces in size, with certain exceptions, when the infant is from twenty-eight to thirty-two months of age, which Wasson calls the thymic cycle.

Certainly all overweight children should

have the benefit of roentgen examination, and it is essential in those of average weight. All agree with Wasson that many patients are treated indiscriminately when roentgenograms made by chance show a large thymus. Under two years of age, Wasson finds it is advisable to treat only those patients with large thymuses in whom an operation is necessary, or when the infant may be having some symptoms which are definitely due to an enlarged thymus. He writes, "I have seen patients under two years of age treated by irradiation when the roentgenogram happens to show a moderate size thymus and yet may not this thymus be performing its proper function?"

The answer to our first query is clear. An infant presenting an enlarged thymus with symptoms should have radiation treatment. An infant presenting an enlarged thymus without symptoms need not have irradiation, unless an operative procedure with general anesthesia is contemplated because in this instance an enlarged thymus may represent the normal growth of the gland.

After the second or third year of life, although the thymus may be increasing in size, the chest is growing at a much greater rate, so that the portrayal of a "broadened mediastinal shadow" on the roentgenogram should suggest a pathological deviation from the normal.

Since our second query concerns the enlarged thymus without symptoms in children, it is not necessary to consider here tracheobronchial adenitis or lymphosarcoma or thymoma except to say that any of these conditions sufficiently advanced to give a broadened mediastinal shadow would carry with them a very definite clinical as well as a roentgenological picture.

I am therefore presuming that the 6 or 7 per cent of cases of "broadened mediastinal shadow" seen in children without symptoms represent at least relatively enlarged thymus glands. No one who is informed thinks for a moment that all of this group represent pathological glands. This group comprises, undoubtedly, those which have not undergone accidental involution from disease, those in whom the rate of chest growth has not kept pace with the thymus, as well as those glands considered potentially a menace.

CONCLUSIONS

Since there is no evidence that the thymus is not an integral causative factor in the type of death under discussion, and since it is known that involution of the thymus takes place rapidly and *without harm* (Hammar) following roentgen or radium treatment, it would appear not only desirable but requisite, until such time as more exact knowledge or experience shall warrant a contrary opinion, to prescribe radiation therapy for those children presenting roentgen evidence of "broadened mediastinal shadow" without symptoms in whom general anesthesia or surgery is contemplated.

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DISCUSSION OF PAPERS OF DRS. TAYLOR AND KINNEY AND OF DR. O'BRIEN

DR. R. D. LEONARD, Boston. I should like to suggest a word of caution along the line spoken of by Dr. O'Brien at the beginning of his paper. Unfortunately, perhaps, in medicine we have to continually revise our working hypotheses. We have to construct some theory along which to work, and as our empirical results and our interest and enthusiasm in this theory develops we subconsciously forget that we are working simply on a hypothesis.

I think this is something we need to bear in mind in relation to this thymus problem. As we see from these two papers, we know what is generally thought about the thymus gland, but very little has actually been proven.

In Boston, as in various other places, the thymus gland is at the present time a popular subject for discussion. Our obstetricians are very much interested in the thymus gland. Nearly all infants are *x*-rayed promptly and if any sort of a shadow is seen in the mediastinum, treatment is instituted. In the sudden, unexplained deaths, we recognize the thymus gland as a probable cause. Therefore on account of the present popular interest in the thymus gland, I would add this word of caution that, as far as possible, we as roentgenologists should be sure that we know what we are talking about.

In a series of 3000 cases of whooping cough in children who were otherwise normal there was a high percentage of what I call large thymus glands—between 15 and 20 per cent. I grant that a certain number of these may have been enlarged by the whooping cough. When it is realized that thymic death, status lymphaticus, ordinarily is not a death from suffocation but may, as Dr. O'Brien has pointed out, in some manner be associated with adrenal hypertrophy or other activity, it having been noted in experimental work that removal of part of the adrenal gland causes hypertrophy of the thymus gland, and also that a large percentage of patients sent to the roentgenologist for thymic asthma or other symptoms alleged to be due to the thymus may, in fact, be suffering from some disturbance indirectly associated with the adrenal function, it behooves us to be careful about the treatment of such cases and to be sure that the child is not suffering from some disturbance other than the thymus.

Dr. E. C. Samuel, New Orleans, La. In 1923 in co-operation with the department of pediatrics of Tulane University, Dr. DeBuys in charge, we started an investigation similar to that which has been made elsewhere in regard to the thymus before anesthesia and at birth. This apparently in the last four or five years has been considered a new subject, and yet in going over some of the literature we found that in 1861 Rokitansky, a Russian, wrote upon hyperplasia of the lymphoid system with special reference to a hyperplasia of the thymus. In our investigation, we were unable to reach any final conclusions, just as were the two speakers this afternoon, as to size of the gland in relation to the child's weight, or other standards of comparative measurement, and we were also unable to prove any relation to congenital heart disease.

We had to reach some definite conclusion as to what our dosage was going to be at that time. We used various methods of treatment, among which was radium, using 100 mg. for a certain length of time over the thymic area. This we have discontinued. We now employ roentgen therapy alone. The following is quoted from a previous publication: "Our roentgen-ray dosage, our method of choice in thymus irradiation, will possibly seem rather mild, but we feel that our best reply to any question of its adequacy is to refer our critics to our results. We have yet to encounter a case of thymic enlargement that has not been controlled with this method. We have tried various techniques of treatment, from 1 to 3 mm. aluminum filtration; from 5 to 7 inch spark gap; 5 ma., 10 in. distance, from 1 to 3 minutes' time, and we have finally settled on uniform exposures of 1 min., 7 inch gap., 5 ma., 1 mm. aluminum filter, 10 in. distance, this giving approximately one-tenth of a skin unit."

We give the child such a treatment and in one week repeat this exposure and usually make an examination of the chest, and if the thymus is reduced in size we stop treatment. If it is not, usually two or three more exposures are given. We have not seen a thymus which has not been controlled by this treatment. There may be a persistence in the size of the thymus with no thymic symptoms, which is a thing which we should consider very carefully.

Dr. H. K. Pancoast, Philadelphia. The treatment of enlarged thymus is the most satisfactory procedure that radiologists have because the cases are many. The cases are all cured either actually or psychologically, and by psychologically I mean in the eyes of the pediatrist or the parents. Nevertheless, I think the radiation treatment of this condition has come to stay even though at the present time I do believe it is greatly exaggerated, as Dr. Leonard intimated.

I heard a very satisfactory description of an enlarged thymic shadow; it is a wide shadow in the region of the thymic gland. It must be noted whether the exposure is made during inspiration, expiration or some where in between; there is a vast difference. During inspiration we find the shadow is almost always about half the width it is during full expiration, but the width of the shadow does not give the true story; the thymus is spread out in more than one direction; it has thickness as well as width, and certainly it is the thickness of the gland that is likely to cause obstruc-

tion. A lateral view of the chest not only gives the exact thickness of the gland, but it gives the relation of that gland to the trachea, that is whether it is distorting or compressing the trachea, and we pay very little attention to the ordinary anteroposterior view of the chest in an infant so far as the thymus is concerned. It is the lateral view which gives the most accurate information concerning the thickness of the gland and possibility of compression of the trachea, if compression is the cause of the trouble. I have always thought it was until a little remark dropped by Dr. O'Brien caused me to stop and think about the possibility of some disturbance in the recurrent laryngeal nerve because there have been some cases in which we thought the obstruction was laryngeal rather than lower down, and yet nothing could be found there.

You can nearly always tell when a child is being examined as to whether it has obstruction or not by the way it cries. If there is not the characteristic "crow" while the child is being examined I am pretty well convinced that I am not going to find anything wrong with the child. If I do get the characteristic "crow," and the child begins to turn blue during the examination, then I know we are up against a rather serious proposition.

I am very glad to hear of the small doses that are given. We have never given over one-quarter of a skin unit dose to a very young infant through one portal of entry. In an older child we never give over one-half of a skin unit dose through one portal. That is likely to have to be repeated again in a week, sometimes not. If we have to repeat it more than twice, we are pretty certain we are not dealing with enlarged thymus, or enlarged thymus alone. It must be something else. That dosage need not alarm us so far as any deleterious effect upon the thyroid or parathyroid is concerned.

I just want to say one word about the use of the roentgen ray. I have examined a few cases which have so alarmed me during the progress of the examination alone that I have been afraid to use the roentgen ray because of the time element involved. I have been afraid they might die during treatment. In those few cases, which I think were probably not more than three, we have recommended a radium pack.

We believe there is a certain amount of—I am almost afraid to utter the word "stimulation" any more—stimulation, or whatever similar word might take its place, of the gland following treatment because we have noticed so many cases where the child is a little worse for possibly six to twelve hours afterwards. This was very noticeable in our own mortality. The child had an obstruction to respiration immediately following birth and artificial respiration had to be kept up. The child was given very short treatments, and whether the parents tired of the artificial respiration during the next six or twelve hours or whether the child's obstruction got a little worse I do not know, but at any rate it died.

A word in regard to enlargement of the thymus in adults, which is a condition that has been greatly exaggerated in the past. In a large goiter clinic such as we have we examine a great many patients for this supposed condition. We found a large number of adults who had what appeared to be an enlarged thymus, and before thyroidectomies these patients were treated until one day a patient who seemed to have an unusually large thymus died, and autopsy showed he had none at all which brought to our minds that we had to find some other explanation for the shadow which we supposed to be the thymus. We believe now it was the shadow of the superior vena cava or innominate, or both.

Dr. Ralph S. Bromer, Philadelphia. Following Dr. Pancoast's advice, at the Children's Hospital we use the lateral view which is quite necessary, I think. It should not be made with the arms above the head, but with the arms behind the back. In that way a clear view of the trachea is obtained. With the arms above the head the trachea will be obscured and you will have no idea of the width of its shadow. There will be not only the question of the actual compression and narrowing of the tracheal shadows but, as Dr. Pancoast feels, there is also a question of the actual width between the spine and the trachea itself.

Dr. W. W. Wasson, Denver, Colo. I should like to add a word of caution to that already given by Dr. Leonard and Dr. O'Brien.

Dr. O'Brien has given a very excellent presentation of the subject leaving it for you to choose what position you would like to take in regard to our present knowledge of the thymus gland.

Our knowledge of the function of the thymus gland is in a debatable state at the present time. I think, though, there are a few things that we might tie to. If we will study the same child from birth through a period of years we will get a little different conception of the gland from what we will if we hold an occasional post mortem or make an occasional roentgenogram of the chest.

In going over such a series, I ran across this

situation: At birth we may have a small thymus, but as we make successive roentgenograms at one-month intervals we find usually around the twelfth month that the gland will show its largest breadth and then will gradually disappear until twenty-eight or thirty-six month when we will have a normal contour of the mediastinum. Such a study, however, must be preceded by a thorough knowledge of the mediastinal structures, and by a thorough knowledge of technique, as Dr. Pancoast suggested. Whether the examination is made at inspiration or expiration or whether the child is turned slightly makes a great deal of difference.

In going over a series we had to examine nearly 300 cases in order to get 135 properly taken films, so we must start with the knowledge of the mediastinum, with the technique, and then if we will follow individual cases from birth through a period of years we will get the physiological change in the size of the gland, as shown in the roentgenogram.

If a child under one year of age comes to us with a noise underneath the sternum, and a roentgenogram is taken, the chances are that we will find evidence of a fairly large thymus. The pediatrician then wishes to have that child treated. If we find no evidence of a large thymus the pediatrician will say the *x*-ray does not portray the actual situation. He suggests that the child be treated anyway, so that irrespective of what the roentgenogram shows the child is pretty apt to get a roentgen treatment.

Thinking that there might be some coincidence, we went still further in the situation. We thought perhaps that the stridor was a coincidence with the large thymus, so we took a series of cases and studied the increase in the size of the thymus in a child, or several children, that had so-called thymic stridors. We assumed that if the thymus increased in size the stridor should increase, but that did not hold true. Such a condition could not be explained by the fact that the trachea increased in its strength sufficiently to offset the growth of the thymus.

We then gave a series of these cases of so-called thymic stridor other treatment than roentgen therapy. We placed them on treatment directed toward infection and mucus in the trachea, and we found they uniformly got better without roentgen treatment.

Our conclusion from that series was that the thymus was probably a small factor in the thymic stridor, and that the stridor was due to mucus in the trachea or else a bronchosinusitis disease. In going over quite a group of cases I have now come to the conclusion that any case with thymic stridor is entitled to a roentgen examination of the sinuses, and I find in the majority of them that there is infection of the sinuses and probably what we are dealing with is not pressure from the thymus gland but bronchosinusitis disease.

I have a personal communication from Dr. Boyd following the presentation of the material I have spoken of on thymic stridor, and she said that she felt, after reconsideration of the subject, that pressure on the trachea from the thymus is a very rare condition.

Dr. L. T. Lewald, New York City. Dr. Pancoast's lateral views are good, but I think they are difficult to interpret.

I wish he would tell us how to tell when a thymus is enlarged simply by seeing a trachea.

Dr. Pancoast. The trachea and the space between it and the spine. You must get the trachea or your film is no good.

Dr. LeWald. Novak states that the enlargement may be in front and may compress structures in front without necessarily compressing the trachea between the spine and the trachea.

Dr. Pancoast. It won't hurt the sternum any.

Dr. LeWald. No, but the large vessels in the neck. There were several instances mentioned today where the anomalies tunnel through. I still think you might have the pressure that you would not recognize on the lateral. One might deceive oneself by saying, "There can't be any enlargement."

Dr. Pancoast. I never saw any baby that turned blue that didn't show evidence of enlargement in the lateral view.

Dr. David C. Dann, Kansas City, Mo. Along the lines of Dr. Leonard's discussion, I should like to know whether or not in any individuals who are supposed to have died of thymic enlargement, roentgenograms were made before and after death.

I have the information on good pathologic authority that in many cases of accidental death the thymus was found enlarged, and this pathologist expressed the idea that perhaps we have been thinking along one line and have forgotten just the opposite method of thought.

In other words, here is an individual who died suddenly and post mortem showed enlarged thymus, the clinical argument being employed. Is it not possible to argue just the other way around, that in view of many cases of accidental death that did show an enlarged thymus, perhaps the shock was responsible for the enlarged thymus?

Dr. O'Brien (closing). I purposely did not go into the size of the thymus as diagnosed roentgenologically because, of course, that depends entirely on the technique. I follow the technique as outlined by Dr. Wasson. With that technique and the patient prone, and the central ray passing posteroanteriorly on the plate at full inspiration, the mediastinal shadow is found to be greater than twice the vertebral body, and the thymus may be considered enlarged. If some other technique is used, then you have to have your own interpretation as to what is an enlarged thymus. I do not believe it makes much difference whether the plate is taken at full inspiration or full expiration provided the same technique is used enough times so that some conclusions may be drawn from it.

I am very much interested in Dr. Pancoast's description of the lateral examination of the thymus. The only objection I can see to it—and it is not an objection because I have been familiar with it since the first time it was described—is that if you take these patients standing the thymus is a jelly-like mass anyway and, as Dr. Wasson has pointed out, by gravity there will be a drop below the mediastinal space. I probably do not use the proper position, and for that reason I should like to have either Dr. Pancoast or Dr. Bromer explain it in detail.

As to the danger connected with treating the thymus, Hammar has studied the thymus for twenty years and should know something about it. He says there is absolutely no danger from roentgen treatment. The cases he has examined show an emigration of lymphocytes which return rather promptly after the treatment has ceased. That emigration of lymphocytes accounts for the decrease in the shadow.

Dr. Pancoast. We make all our examinations in the prone posture, posteroanterior; they should not be made anteroposterior. The laterals are also made in the lateral prone position, both at inspiration and expiration, with the shoulders drawn back so that the shoulders and scapula will be out of the way, and then you get the full expansion of the chest all the way back to the spine. The position of the jaw is very important in making the lateral view. In one the jaw should be up, and in another one the jaw should be down. You will find considerable difference in the trachea. We usually have it about the mid point.

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Information of interest to all readers will be found on page ii.

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EDITORIALS

THE IMPORTANCE OF THE NICHE DEFORMITY IN GASTROJEJUNAL ULCER

FOR over thirty years gastroenterostomy has been the method of choice in the surgical treatment of duodenal ulcer. The results of such treatment have been on the whole apparently satisfactory, and yet the surgeons themselves are not entirely satisfied with this method of treatment, as shown in the various attempts to modify the operation—notably recently by partial gastrectomy, a procedure too recent to permit of any real analysis of its results.

One of the most serious sequels following gastroenterostomy is marginal or jejunal ulcer, and its frequency is in direct proportion to the growing popularity of this surgical procedure.

A gastrojejunal ulcer is a condition much worse than the original ulcer. It occasions the victim much more pain and discomfort and its surgical treatment is fraught with considerable hazard.

Berg in 1897 was among the first to report a case of gastrojejunal ulcer, and since that time a number of reports have appeared on this subject. The incidence of marginal or jejunal ulcers following gastroenterostomy varies but in the simple gastroenterostomies Patterson, Balfour and others estimate the probable risk as about 2 per cent. If at the same time the gastroenterostomy is performed, the pylorus is closed, the incidence of marginal or jejunal ulcer rises somewhat, though not greatly. It is generally accepted that about two-thirds of the patients who have had a gastroenterostomy have relief of their symptoms, but there is a growing belief and a certain amount of accumulated evidence to show that gastrojejunal ulcer is a more frequent sequel of gastroenterostomy than has been thought. Ström has pointed out that "a marginal or jejunal ulcer does not differ from a gastric or duodenal ulcer in its pathologico-anatomical aspect. They may be simple, callous, perforating or penetrating." These ulcers usually occur at the margin of the gastroenterostomy stoma or in the efferent jejunal loop. These ulcers may penetrate in different directions, into the mesentery, into the greater or lesser peritoneal sac or into the transverse colon, forming a gastrojejuno-colic fistula, as has been pointed out by Mathieu, Sevignoe and others, and one should in all cases of marginal or jejunal ulcer give a barium enema to verify or exclude this possibility.

If these marginal and jejunal ulcers exhibit the same pathologico-anatomic characteristics as gastric and duodenal ulcers, then the roentgen signs should be comparable and their screen images should be somewhat identical; as a matter of fact, they present just such roentgen pictures, only the ulcer is seen in a new situation—somewhat obscured behind the stomach, with normal anatomical relations distorted—and this necessitates a considerable familiarity with the usual appearance of a stomach after gastroenterostomy. As a rule, the barium meal passes quickly and freely through the stoma, leaving no residue at the end of four hours. Some of the barium may pass through the normal duodenal route (if it has not been closed). The stomach is smaller in size and gastric peristalsis is, of course, altered somewhat, both as regards the number and depth of the waves. The stomach is deformed only slightly, though the gastric rugae stand out a little more prominently on the greater curvature side proximal to the stoma. The proximal ileal loops are as a rule somewhat dilated. When an ulcer occurs at or near the stoma, this picture is altered. The stomach is usually spastic; it may be considerably deformed; there may or may not be the same free egress of food, the stoma being spastic, and if one observes very carefully just as the first bit of barium sulphate passes through

the gastroenterostomy stoma there may be seen, if an ulcer is present, a niche deformity which is the telltale roentgen evidence of marginal ulcer. While this is, as Case has pointed out, "the one direct sign of a gastrojejunal ulcer," its demonstration may be difficult. So much so in fact that most observers are accustomed to depend upon the indirect signs such as spasm of the stomach, retention of a part of the meal, large sized stomach, exaggerated peristalsis, lessened mobility of the stomach, spasm of the stoma, amounting almost to complete occlusion and local irregularity of the jejunal contour. Gastric retention of the barium meal beyond the four-hour period is not common in marginal and jejunal ulcers and neither is spasm about the stoma; the jejunal loops near the ulcer may or may not be dilated.

Ström (1923) was among the first to point out the importance of the niche as an important diagnostic point in the diagnosis of marginal and jejunal ulcers, and more recently Camp (1928) has called attention to its importance, and he emphasizes the fact that this sign "may be present when other signs fail." He also calls attention to the important observation that the majority of these niche shadows are located in the jejunum and that if the roentgenologist confines his search to the gastroenterostomy stoma the lesion may be overlooked. Camp emphasizes the importance of careful palpation "under the fluoroscope with the patient in the upright position. The stomach should be empty and the anastomosis and contiguous areas explored first with only a swallow or two of barium sulphate in the stomach. By approximating the gastric walls, the gloved hand permits the barium to descend slowly across the rugae to the gastroenterostomy opening. Gentle pressure at this point will demonstrate the site of the anastomosis, and as the release of the hand pressure permits the barium to enter the jejunum, the direction of the loop can be ascertained. If the entire meal is given at once, the rapid egress through the stoma and the overlying loops of jejunum will hopelessly obscure the field. Stomal and jejunal craters invariably fill with the first swallow of barium and the niche is best seen at this time. It will stand out as a remaining shadow of increased density in the stoma, or as a projection about 1 cm. in diameter, from the contour of the jejunum."

This niche deformity simulates to a marked extent infolding of the mucosa, and care must be taken to exclude this possibility. Should the ulcer be on the posterior or anterior wall it may be easily overlooked. Spasm is usually an associated finding and in the experience of some observers, if pressure is made over the suspected area the patient experiences considerable pain.

While niche deformity is the most reliable roentgen sign of gastrojejunal ulcer its demonstration is not always easy. However its demonstration is possible and since it offers the surest evidence of gastrojejunal ulcer, roentgenologists should familiarize themselves with the technique of its demonstration; especially is this true when we realize that gastrojejunal ulcers are much more frequent than is generally thought.*

L. R.

ROENTGEN-RAY AND RADIUM PROTECTION

In an editorial published in the December, 1928, issue of the Journal attention was called to the Recommendations adopted by the Second International Congress of Radiology for the protection of roentgen-ray and radium workers and the recommendations were published in full in that number.

These Recommendations may now be had in pamphlet form (Circular of the Bureau of Standards, No. 374) for the modest price of five cents, by writing to the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. We cannot too strongly urge those who have to do with roentgen rays and radium to familiarize themselves with these important proposals and recommendations.

* During the last two and a half years the writer has seen 14 marginal and jejunal ulcers verified at operation and the important diagnostic point in these was the niche deformity, with tenderness over the ulcer area.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this column solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. John T. Murphy, 421 Michigan Ave., Toledo, Ohio.
Thirtieth annual meeting: Hotel Pennsylvania, New York City, Sept. 17–20, 1929.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Dr. Albert Soiland, 1407 S. Hope St., Los Angeles, Calif.
Annual meeting, Portland, Oregon, 1929.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. Fred M. Hodges, 801 West Grace St., Richmond, Va.
Annual meeting, Portland, Oregon, July 8–12, 1929.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. Walter T. Bronson, Northwestern Univ. Med. School, Chicago, Ill.
Fifteenth annual session: New Royal York Hotel, Toronto, Canada, Dec. 2–6, 1929.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL SOCIETY
Secretary, Dr. Lowell S. Goin, Wilshire Medical Building, Los Angeles.
Meets on the third Wednesday of each month at the California Hospital.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. W. S. Lawrence, Medical Arts Bldg., Memphis, Tenn.

BUFFALO RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St.
Meets second Monday of each month except during the summer months, the place of meeting to be selected by the host.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. W. T. Bronson, Englewood Hospital.
Meets monthly on second Thursday from October to May (except during month of December) at Virginia Hotel. Dinner at 6 P.M., scientific session at 8 P.M.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. Harry L. Farmer, 2930 Prospect Ave.
Meetings are held at 6 o'clock at the University Club, on the fourth Monday evening of each month from September to April, inclusive.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital.
Meets monthly on second Friday from October to May, at Wayne County Medical Society Building.

CENTRAL ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. H. C. Kariher, Decatur, Illinois.
Regular meetings held quarterly.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. J. N. Collins, Indianapolis, Ind.
Annual meeting each February 22 in Indianapolis.
Next meeting in Evansville, Ind., June, 1929.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. J. E. Habbe, 221 Wisconsin Ave., Milwaukee.
Meets first Friday in October, December, February and April.
Place of meeting designated by the president.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. M. C. Sosman, Peter Bent Brigham Hospital, Boston, Mass.
Meets monthly on third Friday, Boston Medical Library.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. E. Everett Rowell, 200 West 59th St.
Meets monthly on third Monday, New York Academy of Medicine.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. D. S. Childs, 316 Gurney Bldg., Syracuse, N. Y. Three meetings a year—April, August and November.

PACIFIC COAST ROENTGEN RAY SOCIETY
Secretary, Dr. Harold B. Thompson, Seattle, Wash.
Two meetings a year.

ROENTGEN RAY SOCIETY OF CENTRAL PENNSYLVANIA
Secretary, Dr. W. E. Reiley, Clearfield, Penna.
Two meetings a year, April and October.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary Dr. John T. Farrell, Jr., 235 S. 15th St., Philadelphia.
Meets monthly on first Thursday evening, Pennsylvania Hospital.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. James M. Flynn, 282 Alexander St.
Meets monthly on the first Friday evening at 7.45 at the Rochester Medical Association Building.

ST. LOUIS ROENTGEN CLUB
Secretary-Treasurer, Dr. L. R. Sante, Metropolitan Building.
Meets first week of each month. Time and place of meetings designated by president.

TEXAS RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. C. P. Harris, Houston, Texas.
Meets annually one day preceding the meeting of the Texas State Medical Association.

VIRGINIA ROENTGEN RAY CLUB
Secretary, Dr. Wright Clarkson, 205 S. Sycamore St., Petersburg, Va.
Annual meeting, Charlottesville, Va., Oct. 18, 1929.

British Empire

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Director, Dr. John Muir, 32 Welbeck St., London, W. 1.

* Secretaries of societies not here listed are requested to send the necessary information to the editor.

Meets on the third Thursday of each month, from November to June inclusive, at 8.15 P.M., at 32 Welbeck St., London, W. 1., or as advertised.

ELECTRO-THERAPEUTIC SECTION OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8. 30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.
Third session, Sydney, Sept. 2–7, 1929.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

SECTION ON RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch.
Meets annually.

Continental Europe

BELGIAN SOCIETY OF ROENTGENOLOGY
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

SOCIETE DE RADIOLOGIE MÉDICALE DE FRANCE
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

SOCIETE FRANCAISE D'ELECTROTHÉRAPIE ET DE RADIOLOGIE MÉDICALE
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

ASSOCIATION OF GERMAN ROENTGENOLOGISTS AND RADIOLOGISTS IN CZECHO-SLOVAKIA
Secretary, Dr. Walter Altschul, German University, Prague, 11/52.

DEUTSCHE RÖNTGEN-GESELLSCHAFT (GESELLSCHAFT FÜR RÖNTGENKUNDE UND STRAHLENFORSCHUNG)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

SUD- UND WESTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

NORD- UND OSTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

DUTCH SOCIETY OF ELECTROLOGY AND ROENTGENOLOGY
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

SOCIETA ITALIANA RADIOLOGIA MEDICA
Secretary, Professor M. Ponzio, University of Turin, Turin.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.
Sixth Annual Meeting, 1929, to be announced.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly on the first Monday at 8 o'clock in the State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. A. Elektorowicz, 19 Hoza St., Warsaw.
Meets annually.

WARSAW SECTION, POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with the exception of the Denmark Society, meets every second month except in the summertime:

SOCIETY OF MEDICAL RADIOLOGY OF SWEDEN
Meets in Stockholm.

SOCIETY OF MEDICAL RADIOLOGY IN NORWAY
Meets in Oslo.

SOCIETY OF MEDICAL RADIOLOGY IN DENMARK
Secretary, Dr. H. Scheuermann, Copenhagen
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

SOCIETY OF MEDICAL RADIOLOGY IN FINLAND
Meets in Helsingfors.

VIENNA SOCIETY OF ROENTGENOLOGY
Secretary, Professor Holzknecht, Vienna, IX, General Hospital.
Meets on the first Tuesday of each month from October to July.

PROTECTION MEASURES IN ROENTGEN LABORATORIES IN HUNGARY

The Royal Hungarian Minister for Public Welfare and Labor called a conference on the subject of protection against roentgen rays and high voltage currents. This conference met under the chairmanship of state secretary T. de Györy, M.D.,

and appointed a committee consisting of roentgen-ray experts and engineers. The chairmen of this committee are Prof. B. Pogány and Prof. B. Kelen, the referee being Prof. N. Ratkóczi. The function of the committee is to work out rules for protection against roentgen rays and high voltage currents, to watch the scientific and technical development of roentgenology and to keep in touch with foreign committees of this kind. The first meeting was held in Budapest on February 4, 1929.

NOTICE OF MEETING

The Section of Radiology and Medical Electricity of the Australasian Medical Congress will hold its third session in Sydney, New South Wales, on September 2–7, 1929. The president of this section is Dr. H. M. Hewlett, 101 Collins Street, Melbourne, Victoria and the secretary, Dr. H. M. Cutler, 139 Macquarie Street, Sydney.

INDIANA ROENTGEN SOCIETY

The Second Annual Meeting of the Indiana Roentgen Society was held in Indianapolis on February 22, 1929; twenty-one members were in attendance. Dr. P. M. Hickey of the University of Michigan who was the guest of honor, gave an address entitled "Lateral Teleroentgenography of the Chest."

The following officers were elected for the ensuing year: President-elect: Dr. C. S. Oakman, Muncie; Vice-President: Dr. K. T. Meyer, Evansville; Secretary-Treasurer: Dr. J. N. Collins of Indianapolis. Dr. E. M. VanBuskirk of Fort Wayne was appointed a member of the Executive Committee for three years. The next meeting of the Society will be held in June, 1929, in Evansville, Indiana.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY *visiting New York City, are invited to make the office of* THE JOURNAL *(76 Fifth Avenue, New York) their headquarters. Mail, packages or bundles may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

Vol. XXI. No. 3

DEPARTMENT OF TECHNIQUE

Department Editor: David R. Bowen, M.D., Pennsylvania Hospital, Philadelphia, Pa.

In this department will be published from time to time, as material is available, suggestions for improvement in technique.

A REALLY FLEXIBLE BED, ESPECIALLY SUITED FOR USE IN HIGH VOLTAGE THERAPY

BY L. H. GARLAND, M.B.

Radiologist to St. Mary's Hospital

SAN FRANCISCO, CALIFORNIA

A DESCRIPTION is given of a simple and perhaps new type of freely adjustable, deep therapy bed which has been in use at St. Mary's Hospital roentgen-ray department for some months.

Fig. 1. Elevating bed in position for treatment with tube above patient. Note that the high tension leads are completely enclosed in the grounded, metal tubing, which is 22 inches in diameter. The lead-lined drum cuts off all radiation except the beam of rays passing through the filter in the nozzle.

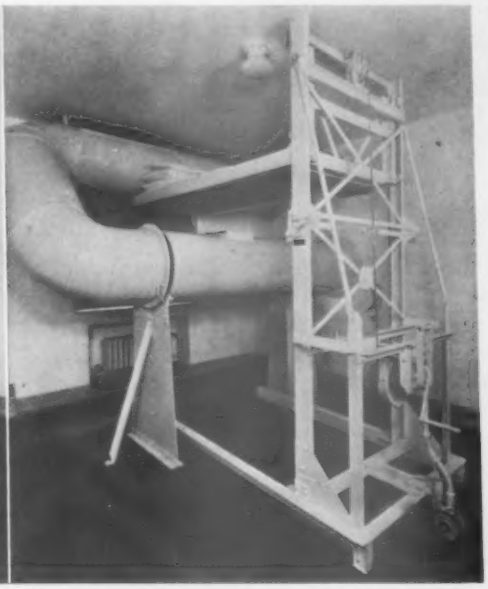

Fig. 2. Elevating bed in position for treating patient from below. Note the plumb bob suspended from the ceiling; this is in the axis of the central ray and facilitates centering. As in Figure 1, the bed is fixed in position, the moving handle being at rest against the back, while the cranking handle is ready for use. The position shown gives a focus skin distance of 70 cm.

By using this bed in combination with a very perfect tube shield, high voltage roentgen treatments can be delivered to any part of a patient's body, with the minimum of inconvenience to the patient and the maximum of safety to both patient and nurse (should an attendant be necessary). In hospital practice many unusual diseases are encountered in patients of various kinds; some who cannot lie face down, some who can lie only face down; others who can only sit, or even only stand. With the apparatus described one can treat with equal exactitude any of these types, frequently repeated doses (e.g., saturation courses) being administered with ease and little discomfort.

The "couch" is an elevating type of bed, which can be lowered practically to the floor and raised to within two feet of the ceiling of a room nearly ten feet high. This enables treatments to be given at

any desired skin distance up to 110 cm. below and 85 cm. above (the tube being enclosed in a rotating lead-lined drum). The bed is raised and lowered by a hand-crank which is easy to operate, and stays locked in any desired position. Slipping is prevented by a braking device which automatically sets itself (when manual pressure on the crank is released).

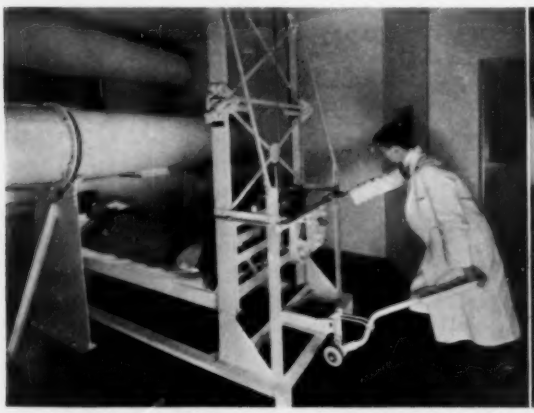

FIG. 3. Elevating bed being pushed under drum, showing method of handling. This handle is used for both pushing and pulling; it lifts the rear supports off the ground, allowing the bed to roll freely.

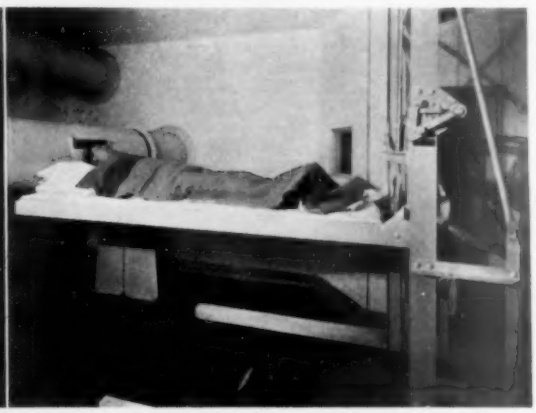

FIG. 4. Bed with patient in position for treating lesion such as a brain tumor. By lowering the bed almost to the floor and placing a chair near the end, similar treatments may be given to the occipital and each parietal region with patient sitting. The position shown gives a 30 cm. focus skin distance.

When it is desired to treat a patient from above, the bed is pulled back by a handle which normally rests against the lifting mechanism. This raises the rear end of the bed, transmitting the weight from the two non-rolling supports to a double castor, and allows the bed to roll freely. The bed is then cranked up to a height sufficient to clear the top of the tube-drum, and is pushed forward *until* the center of the skin field to be irradiated lies approximately under the plumb bob (which is suspended from the ceiling in the axis of the central ray). The patient is now raised to the desired skin distance and accurately centered (having used a skin pencil previously). For treatments below, or at either side, centering is facilitated by measured rods of various lengths.

The bed frame and elevating mechanism form one piece of equipment, the elevating upright being collapsible to allow getting past doors, etc. The bed itself consists of a piece of 5-ply wood, 3 × 7 ft., and six-eighths inch thick; it is covered throughout by a tightly stuffed 2-inch hair mattress.

The following notes concerning the therapy installation itself may be of interest. A mechanically rectified, high voltage transformer system is installed in a separate room and supplies the energy for operating the usual high voltage, air-cooled tube (most of the deep work being done at 200 kv. with 5 ma). A Kearsley stabilizer, with two 9-inch milliammeters,

FIG. 5. View of lead-lined control booth. Shows control stand, with lead glass window immediately above it; to the right of the window is the pilot light for the exhaust fan; to the right of that are the filament ammeter and the remote control for stabilizer. One milliammeter is visible through the glass window on right.

is also mounted in that room, being viewed and regulated from the control booth. A standard sphere gap (125 mm. spheres)

is in circuit. The circuit breaker, also installed in this room is reset by means of a cord in the booth. High tension current is carried by ¾ in. tubular overhead, through two insulators in the wall to the therapy room. In the latter it is covered by a galvanized iron cylinder 22 inches in diameter. This, with the tube container, prevents both noise and corona discharge from entering the room.

The tube is cooled by an exhaust fan mounted in the transformer room (see Fig. 6), the air being partly cleaned by a triple cheese cloth dust filter, held in a wire frame at the upper entrance to the overhead cylinder. The tube container is similar to that described by Chamberlain and Newell.[1] It is lined throughout by 6 mm. lead, weighing about 1000 lb. The only other lead used is that which entirely lines the control booth (the usual 8 lb. sheet lead).[2]

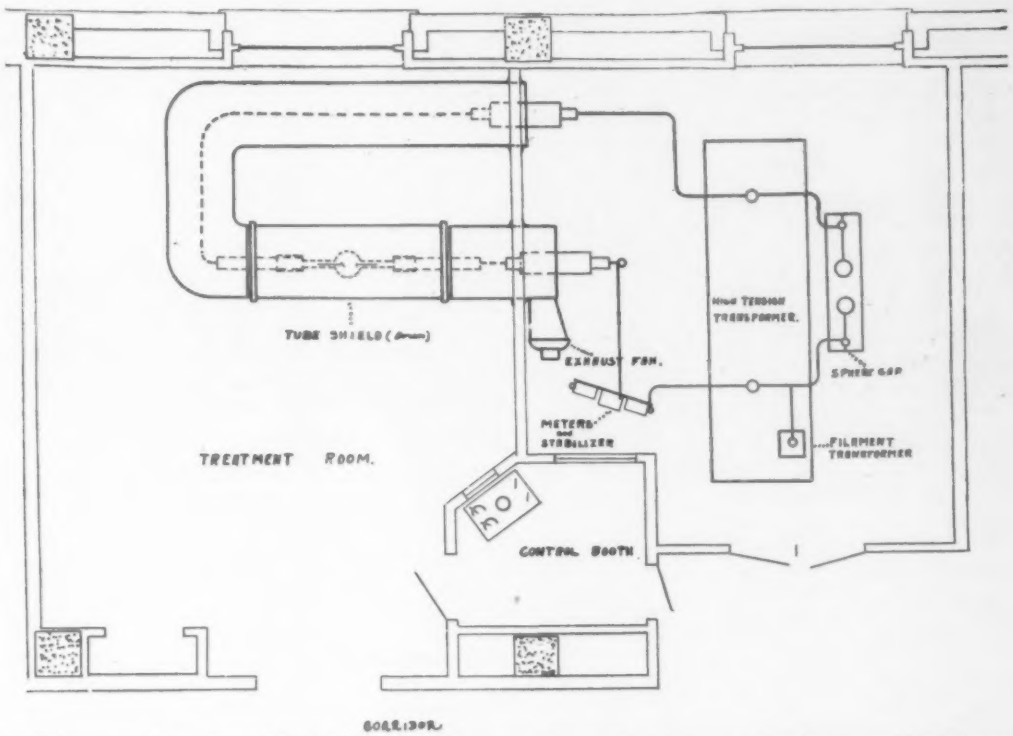

Fig. 6. Diagram of floor plan of the high voltage therapy and transformer room. (Insulators and bakelite supports along the high tension leads are not shown. Diaphragm nozzle in drum is not shown. Note: The roentgen-ray tube is inserted through this nozzle opening and is held in place by hollow bakelite supports which rotate with the drum.)

[1] Chamberlain, W. E., and Newell, R. R. Deep therapy installation embodying some novel features. *Radiology*, 1924, ii, 414–418.

[2] The writer wishes to express his appreciation to Drs. W. E. Chamberlain and R. R. Newell for their untiring interest and advice; and also to the firms who supplied the bed and the equipment, for their invaluable co-operation.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

TUMORS ARISING FROM THE BLOOD-VESSELS OF THE BRAIN: ANGIOMATOUS MALFORMATIONS AND HEMANGIOBLASTOMAS. By Harvey Cushing, Professor of Surgery, Harvard Medical School; Surgeon-in-Chief, Peter Bent Brigham Hospital, Boston, and Percival Bailey, formerly Associate in Surgery, Peter Bent Brigham Hospital; Associate Professor of Surgery (Elect), University of Chicago. Cloth. Price, $7.50. Pp. 219, with 159 illustrations. Springfield, Illinois, and Baltimore, Maryland: Charles C. Thomas, 1928.

The majority of publications dealing with tumors and other lesions of the brain have attempted to embrace the entire subject with consequent superficial studies of the various lesions considered. Cushing long ago saw the need of focusing special attention on certain groups of neoplasms, and in 1917 stated in his "Tumors of the Nervus Acusticus" that "the time is ripe for special studies of special tumors, in special localities, particularly if the surgical treatment of these difficult lesions is to be perfected." The monographs from his clinic have done much to clarify the confusion, both clinical and pathological, regarding brain tumors, particularly the acoustic neuromas, the meningiomas, the pituitary adenomas, and more recently, the gliomas.

The present monograph dealing with the blood vessel tumors of the brain is a fitting sequel to the splendid works which have preceded it. Much confusion has existed in the classification of the blood vessel tumors and abnormalities found in the brain, and no standard nomenclature has been adopted. Thanks to the painstaking studies and detailed histories incorporated in the present volume, a clear understanding of these important lesions is now possible. The correlation of symptoms and operative findings with the pathology and subsequent course is particularly valuable.

Cushing and Bailey divide the gross blood vessel lesions into two groups, the angiomatous malformations and the angioblastomas or true neoplasms. They relegate the loosely applied term of telangiectasis to the comparatively insignificant small capillary lesions which being symptomless are of no clinical importance.

The true angiomatous malformations, both venous and arterial, are considered in detail and the dangers of surgical intervention emphasized. Roentgen-ray treatment is suggested, but with no certainty of improvement in the condition.

The true blood vessel tumors, the angioblastomas are clearly differentiated. Being actual neoplasms complete excision should be practiced when possible. These interesting tumors occur mainly if not exclusively in the cerebellum. Many are cystic and previous to this study have been considered as cystic gliomas.

The book is beautifully printed with exceptionally clear type, and the illustrations are informative and well chosen. The previous paucity of knowledge concerning these lesions, the manner in which the subject is presented, the lucid, free-flowing style characteristic of the writing of the authors, together with the splendid topography of the book, make the work not only invaluable to the neurologist and the neurosurgeon, but one which will furnish pleasant, worthwhile reading for the general profession.

MAX M. PEET.

HANDBUCH DER RÖNTGENTHERAPIE. Three volumes. Edited by Paul Krause, M.D. Pp. 1775, with 336 illustrations. Leipzig: Georg Thieme, 1924, 1927, 1928.

During the past three months, the reviewer has spent many an evening reading the three volumes of the Handbuch, covering a total of more than 1700 pages. In looking over the collection of notes concerning the various contributions, the impossibility of incorporating all into a review of limited space becomes only too apparent. Be it understood then, that only a complete index will be given here with some remarks on chapters which are exceptionally good or which may be supplemented in a new edition. The book as a whole can be recommended for the library of the roentgenologist interested in the therapeutic field.

Due to the fact that part of the book appeared in 1924 and in 1927, while the remainder was published in 1928, the presentation of some of the subjects cannot be expected to be exactly up to date. This is particularly noticeable in the discussion of the apparatus (H. Martius) and in the article on dosimetry (H. Schreus). Throughout the text, doses are expressed in erythema units, and the R unit is only mentioned. The third chapter deals with the effect of roentgen rays on plants (M. Koernicke), followed by an excellent essay on "The therapeutic roentgen irradiation from the patho-anatomical standpoint" (P. Prym). Sound clinical judgment and ripe experience are expressed in Chapter V, "The

roentgen therapy in gynecology" (H. Martius). Next in order are the specialties: Roentgen-ray therapy in skin diseases (R. Habermann and H. Schreus); in eye, nose and throat (K. Amersbach); in surgical diseases (H. Holfelder); in dentistry (K. Schmidhuber). A brief sketch of the therapeutic use of roentgen rays is veterinary medicine is also to be mentioned (M. Weiser).

In the last volume, the chapter on roentgen therapy in ophthalmology (W. Stock) is followed by an extensive contribution under P. Krause's editorship on roentgen therapy in internal medicine. A general part serves as introduction, then two of his assistants (K. Käding and C. Kruchen) discuss the diseases of the entire nervous system, the endocrine glands, the circulatory system, the respiratory tract, the blood-forming organs, the gastrointestinal and genitourinary tracts, bones and joints, and also a number of infectious diseases. The pediatrician will also find discussed problems in his specialty (G. Kohlmann and W. Grävinghoff). Almost two hundred pages are devoted to the presentation of roentgen therapy in surgical diseases by H. Holfelder who has done recognized pioneer work in this field. The "general" chapter by the same author mentioned before ought to be read in connection with this and the two should have been printed close together. A voice of warning rises at the end: Accidents and injuries in roentgen therapy and their legal importance (F. M. Groedel). General safety rules are appended as a supplement.

Most contributions offer a satisfactory bibliography and the majority of the illustrations are well done. While only a rather determined student will take the whole book and "see it through," every physician will appreciate this enormous accumulation of material as an excellent source for daily reference. Ernst A. Pohle.

Electrotherapie. W. Vignal, M.D., Paris. Pp. 519, with 179 figures and 10 charts. Paris: Gaston Doin and Co., 1928.

Since the application of electricity in medicine has increased considerably during the last years, textbooks on this subject covering the latest advances are only too welcome. The practitioner will be pleased, however, to receive a book of the type presented by Dr. Vignal. It is of the nature and of the arrangement of a dictionary, that is, all chapters have sub-headings in heavy print which permit rapid orientation. It starts out with a chapter entitled "Biophysics and Apparatus" where atomic theory, fundamentals of electricity, including measuring instruments, galvanic, faradic and galvofaradic current, static electricity, condensers, and high frequency currents are discussed. The second chapter on "Practical Electrotherapy" deals with the electric diagnostic, nerve and muscle testing, and outlines then the method of treatment for the various diseases of nerves, muscles, central nervous system, circulatory system, bone and joints, genitourinary tract, respiratory system, gastrointestinal tract, in dermatology, disturbances of metabolism and endocrine system, in ear, nose and throat diseases, and in ophthalmology. In an appendix, the accidents due to electric currents and preventive and therapeutic measures are presented.

In the third and last chapter, charts will be found offering all essential information for nerve and muscle testing. This book gives an interesting account of the author's technique and clinical indications for the use of electricity in diagnosis and therapy. As far as the results are concerned, his own words are quoted: "On ne doit pas oublier que s'il y a des maladies, il y a aussi des malades qui reágissent différemment suivant la modalité électrique utilisée."

Ernst A. Pohle.

BOOKS RECEIVED

Tumors Arising from the Blood-vessels of the Brain: Angiomatous Malformations and Hemangioblastomas. By Harvey Cushing, Professor of Surgery, Harvard Medical School; Surgeon-in-Chief, Peter Bent Brigham Hospital, Boston, and Percival Bailey, formerly Associate in Surgery, Peter Bent Brigham Hospital; Associate Professor of Surgery (Elect), University of Chicago. Cloth. Price, $7.50. Pp. 219, with 159 illustrations. Springfield, Illinois: Charles C. Thomas, 1928.

The Theory and Practice of Radiology, with a Synopsis of Radiography and Radiotherapy. A Treatise in Four Volumes. By Bernard J. Leggett, M.R.C.S., L.R.C.P., A.M.I.E.E., Radiologist, East London Hospital for Children; Staff Radiologist, City of London Hospital for Diseases of Heart and Lungs, etc. Volumes I, II, and III. Cloth. St. Louis: C. V. Mosby Co., 1928.

Röntgenology: The Borderlands of the Normal and Early Pathological in the Skiagram. By Alban Köhler, Prof. Dr. med., Wiesbaden. Rendered into English from the Fifth German Edition by Arthur Turnbull, M.A., B.SC., M.B., CH.B. (Glasg.). Cloth. Price, $14.00. Pp. 556, with 324 illustrations. New York: William Wood and Co., 1928.

Die Röntgentechnik in Diagnostik und Therapie. Von Dr. S. Glasscheib, Spezialarzt für Röntgenologie, Berlin-Warschau. Paper, price RM 13.60; bound, RM 14.80. Pp. 292, with 145 illustrations. Berlin: Julius Springer, 1929.

Teeth and Jaws Roentgenologically Considered. (Annals of Roentgenology, Volume V.) By Herman A. Osgood, M.D. Second edition revised. Cloth. Price, $10.00. Pp. 135, with 419 illustrations. New York: Paul B. Hoeber, Inc., 1929.

Roentgenology: Its Early History, Some Basic Physical Principles and the Protective Measures. By G. W. C. Kaye, O.B.E., M.A., D.SC., F. INST. P. Cloth. Price, $2.00. Pp. 157, with 49 illustrations. New York: Paul B. Hoeber, Inc., 1928.

INTERNATIONAL ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

Andren, Gunnar. Contribution to the pyelographic diagnosis of renal tuberculosis. *Acta radiol.*, 1928, ix, 289–295.

The author describes 2 cases where a diagnosis of renal tuberculosis was made by pyelography. In connection with this, the author discusses the importance of the pyelovenous reflux and its differentiation from tuberculosis.

A pyelovenous reflux is produced in pyelography when the distended renal pelvis under relatively high pressure ruptures and the opaque substance enters through the vena arciformis into the venous system of the kidney. The rupture, as a rule, occurs at the end of a calyx and the roentgenogram shows one or more narrow streaks extending from the calyx towards the renal substance. These narrow streaks indicate the entrance of the injected opaque substance into the venous system. In a collection of 150 pyelographies 6 cases of pyelovenous reflux were found. It does not always happen that rupture of the calyx leads to a pyelovenous reflux. The opaque contents may also spread to the hilus of the kidney and underneath the capsule. According to Fuchs the proportion between pyelovenous reflux, extravasation into the hilus sinus and subcapsular extravasation is 70:15:15. In renal tuberculosis a condition similar to that of pyelovenous reflux resulting from fistulae is sometimes observed, but the more mottled appearance of the entire calyx due to the tuberculous infiltration, especially in the later stages, as a rule helps in the differentiation. In the 2 cases described the roentgen diagnosis was verified at operation.—*T. Leucutia.*

Béclère, A. Roentgen diagnosis of tumors of the brain. *J. de radiol. et d'électrol.*, Dec., 1928, xii, 570–589.

If there is the least sign of brain tumor roentgen examination of the skull and brain becomes absolutely imperative. Simple roentgenography should be used first as it is absolutely harmless. Needless to say, it should be practiced by a neuroradiologist with the most careful technique. Roentgen examination of the skull may show different kinds of bone lesions including lesions not dependent on tumor of the brain but which may cause the brain symptoms, such for example as a syphilitic osteitis of the inner table of the skull; lesions caused by acromegaly and therefore showing the existence of an adenoma of the hypophysis which requires roentgen therapy; symptomatic lesions due to very high intracranial pressure; localized lesions due to the existence of a tumor which irritates the meninges; changes in the petrous bone which help in the diagnosis of tumors of the cerebellopontile angle, particularly tumors of the auditory nerve; malformations and changes in the sella turcica which show an adenoma of the hypophysis or an extrasellar tumor and which are of value in differential diagnosis.

Roentgen examination of the brain may show calcareous concretions which are frequent normally in the pineal gland, and their displacement is an indirect sign of value in the diagnosis and localization of intracranial tumors. It may also show meningiomas or even gliomas if they are sufficiently calcified. Very often too it shows suprasellar tumors of Rathke's pouch, the great majority of which contain calcareous concretions which are absolutely pathognomonic.

Encephalography is based on the introduction of gas or opaque substances into the cavities of the brain in order to differentiate them from the surrounding tissues by their transparency or opacity to roentgen rays. These methods are called gaseous and opaque encephalography. Gaseous encephalography (Dandy's method) is based on insufflation of the ventricles after removing all or part of their liquid content. It shows changes in the form, site and size of the ventricles if there is a large enough tumor of the brain; it also helps indirectly in the localization of the tumor but does not show its nature. The interpretation of the pictures is often difficult and delicate. Opaque encephalography gives indirect information of the same kind. There are three different methods, one the injection of lipiodol into the ventricles, one the injection of sodium iodide into the arteries, and the other the injection of lipiodol into the veins and sinuses. The two latter methods are too new for judgment to be passed on them. The use of lipiodol for the diagnosis of compression of the brain unfortunately does not give results comparable to those obtained in compression of the spinal cord. Lipiodol myelography is an admirable method which is as harmless as it is exact, but Sicard himself admits that his method of ventriculography is painful, dangerous and

not entirely reliable. Ventriculography with gas is very much superior to it. It is not free of danger either and may even cause death. It may not give any results at all or even deceptive ones. But it may also show the site of a tumor and permit of its total or partial removal. But insufflation of the ventricles should not be resorted to until clinical observation and simple roentgenography have failed to show the site of the tumor.

Belluci, B. Roentgen and clinical study of post-typhoid lesions of the bones and joints. *Radiol. med.*, Dec., 1928, xv, 1180–1208.

The author describes the clinical, pathological and roentgen lesions of the bones and joints following typhoid fever. He reviews the literature of the subject and describes experimental work of his own accompanied by an analysis of the reasons why the typhoid bacillus sometimes becomes localized in the bones and joints; there are three principal types of localization leading to osteoperiostitis, osteomyelitis and osteoarthritis. He discusses the probable reasons why the localization is more frequent in certain bones than others and mentions the most important clinical characteristics of these lesions, including a very long latent period and great benignancy. He then describes the roentgen lesions themselves and makes a careful comparison of the roentgen pictures with the anatomicopathological pictures.

A considerable part of the article is devoted to a discussion of post-typhoid changes in the spinal column, as roentgen examination is of special value in the differential diagnosis of these lesions from Pott's disease; in many cases it is very difficult to make this differentiation clinically. He then reports some cases of post-typhoid osteoarthritis which he has seen himself, including 3 extremely rare cases of spondylitis which are particularly interesting.

Hjelm, R., and Hultén, O. Roentgenological study of the lobe of the azygos vein. *Acta radiol.*, 1928, ix, 126–135.

The first case of azygos lobe was described by Wrisberg in 1778, whence it is called also lobus Wrisbergi. The authors describe 13 cases which they have collected from the Anatomical Institute of Upsala. The roentgenological appearance of all these cases was studied and it was found that the most characteristic feature of the condition is a narrow streak running over the upper and medial aspect of the apex downward toward the lung hilus where it ends in a drop-like shadow. The narrow line is due to the roentgenological projection of the parietal pleura which duplicates between the upper lobe and the azygos lobe. The drop-like shadow corresponds to the cross-section of the vena azygos which for a small distance runs posteriorly towards the hilus and thus it is caught in the transverse projection.—*T. Leucutia.*

Hultén, Olle. Anatomical variations of the bones of the carpal joint. A contribution to the genesis of two different changes of the semilunar. *Acta radiol.*, 1928, ix, 155–168.

Four hundred roentgenograms of normal carpal joints were examined over a period of fifteen years with regard to the relationship of the ulna, radius and semilunar. In 61 per cent of the cases the ulnar and radial surfaces of the carpal joint are on the same level; in 39 per cent of the cases there is a variation, in 23 per cent the ulna being shorter and in 16 per cent the ulna being longer (in 15 per cent the ulna was 1 mm. shorter, in 10 per cent 1 mm. longer; in 1.5 per cent, 2 mm. shorter, in 4 per cent, 2 mm. longer; in 2 per cent, 3 mm. shorter and in 1 per cent, 3 mm. longer; in 0.3 per cent, 4 mm. shorter and in 0.5 per cent, 4 mm. longer).

The greatest difference in the level between the ulna and radius amounted to 6 mm. This forms the extreme variation as yet considered normal, the next grade belonging to abnormalities such as ulnar hyperplasia or Madelung's deformity.

The traumatic malacia of the semilunar (Kienböck) shows a tendency to occur in cases with a shorter ulna. It is most probable that the difference in the level of the joint predisposes to a development of Kienböck's malacia. The difference in level also plays an important part in certain injuries to the disc and joint cartilages.

In the material examined not one case of lengthening of the ulna was associated with a malacia of the semilunar. A cyst-like thinning of the ulnar portion of the semilunar, however, was often observed. The author therefore arrives at the conclusion that, of the two changes of the semilunar, Kienböck's malacia is always associated with a shortening of the ulna, while the cyst-like rarefaction of the semilunar is observed in cases with lengthening of the ulna.—*T. Leucutia.*

Hultén, O. Contribution to the roentgen diagnosis of acute pancreatic affections. *Acta radiol.*, 1928, ix, 222–254.

The roentgen signs of acute pancreatic affections are insufficiently known, the chief reason being that a roentgen examination is of only limited value. The author proposes to

demonstrate that there are signs, especially on the part of the adjacent organs, which make the diagnosis of acute pancreatic affections possible.

The pathological classification of acute pancreatic affections into pancreatic necrosis and pancreatitis have from the roentgenologic standpoint little importance. The anatomical extension of the process to adjacent organs, however, can in the majority of the cases easily be detected roentgenologically; thus an indirect diagnosis can be made. There are four types of anatomical extension of the process: (1) Free peritonitis with serous or serohemorrhaginous exudate in the entire abdominal cavity and with fat necrosis in the omentum and peritoneum; (2) a circumscribed exudate localized to the bursa omentalis as a result of the closure of the foramen of Winslow; (3) retroperitoneal hematoma or retroperitoneal phlegmon which extends into the fat capsule of the left kidney and from there toward the diaphragm or downward along the descending colon; (4) changes localized exclusively to the pancreas.

Roentgen Symptoms. The following are the most important roentgen symptoms: (*a*) Tenderness on pressure. This can be detected in conjunction with the barium meal when the barium-filled duodenum serves to localize the site of the pancreas. If a barium meal cannot be administered (because of the advanced condition of the lesion) the above symptom is without value. (*b*) A tumefaction in the region between the stomach and the transverse colon which, as a rule, is tender on palpation. This tumefaction is due partly to the acutely swollen pancreas and partly to the exudate in the bursa omentalis. Körte considers this as the most important symptom in acute pancreatic necrosis. (*c*) Secondary involvement of the diaphragm, pleura and lungs. The process extends along the left kidney toward the diaphragm producing diaphragmitis. This, as a rule, cannot be determined during roentgenoscopy in the sagittal plane, the appearance being entirely normal, but by examining the patient in the lateral view a lagging of the posterior portion of the dome of the left diaphragm is observed on deep inspiration. The dome of the right diaphragm maintains its normal function. In other cases there is evidence of exudate in the left phrenocostal sinus which with the progress of the disease often develops into an empyema. In such a case there is the typical picture of a subphrenic abscess with secondary exudate in the pleural cavity. This form of acute pancreatitis is called by Guinard the thoracic form and is almost always localized to the left side. (*d*) Indistinct outline of the psoas muscle on the left side. This is observed in the cases where extension of the process is downward in the caudal direction. (*e*) Changes observed in the stomach and duodenum. In the cases with closure of the foramen of Winslow an exudate develops in the bursa omentalis, having the appearance of a pseudo-cyst which displaces the stomach forward and toward the left. In very advanced cases a spherical pressure defect on the lesser curvature is observed. The duodenal bulb is distended by gas and is often visible without contrast media. This collection of gas, which no doubt originates from the stomach, is probably due to the lessened peristalsis. The entire duodenum is atonic and sluggish. In some instances a peculiar folding of the mucous membrane of the duodenum is seen which is due to the edema and hyperemia produced. (*f*) Changes in the appearance of the intestine. There is a marked gas distention, especially of the transverse colon, which is explained by the pressure of the exudate on the mesocolon. In a later stage where there is a generalized peritonitis with fat necrosis and serohemorrhaginous exudate of the entire abdominal cavity, there is a gas distention of the intestines such as is observed in ileus. (*g*) Association of the process with gall-bladder conditions. Gallstones or diffuse enlargement of the gall-bladder as a rule confirm the diagnosis of pancreatitis. Schmieden has observed that in 70 per cent of the pancreatic necroses (out of 1278 cases) there was evidence of gall-bladder disease.

A differentiation of acute pancreatic affections has to be made from certain other acute abdominal conditions. In cases of differentiation from gastric ulcers the presence of free gas in the abdomen makes the diagnosis of perforated ulcer certain. In the differentiation from ileus, especially that due to strangulation or obliteration, the roentgen examination is of great value. The typical picture of ileus is well known. It is more difficult and sometimes impossible to differentiate between a left-sided perinephritis and acute pancreatitis. Association with gall-bladder disease would to a certain degree indicate pancreatitis.

Method of Examination. If a patient is acutely ill, roentgenoscopy of the abdomen as well as of the chest is done in the recumbent position. Then a flat film of the abdomen is taken. If possible it is advisable to do a roentgenoscopic examination also in a sitting position to determine the presence of small amounts of fluid in the pleural cavity which in the recumbent position may escape detection. It is also advisable to give a very small amount of barium in order to study the condi-

tion of the duodenum. In the subacute or chronic cases of pancreatitis a complete barium meal can be administered.—*T. Leucutia.*

Jansson, Gösta. Gastrocolic fistula, especially from the roentgenological standpoint. *Acta radiol.*, 1928, ix, 9–22.

The most common causes of gastrocolic fistula are: carcinoma of the stomach or colon, gastric or jejunal ulcer following gastroenterostomy, in rare cases tuberculosis of the colon, abdominal abscess or congenital anomaly. The author describes 3 cases of gastrocolic fistula, each of which developed following perforated gastric ulcers. In one of the cases the fistula was visualized only after the barium meal had entered the colon. In the two others the demonstration was made by means of the barium enema. The author emphasizes the necessity of making repeated observations on the colonic tract following the administration of the barium meal and combining the examination always with a barium enema. In none of the cases could it be foretold from the observation of the barium filled stomach that there was present a gastrocolic fistula since the passage of the barium from the stomach into the fistula could not be observed.—*T. Leucutia.*

Lindblom, Adolf F. Roentgenological changes of the stomach and duodenum in pancreatitis. Preliminary communication. *Acta radiol.*, 1928, ix, 255–265.

Fourteen cases of acute and chronic pancreatitis were examined with regard to the changes produced in the stomach and duodenum. The following roentgenologic modifications were observed: (1) displacement and deformity of the curvature of the duodenum due to the tumefaction of the head of the pancreas; (2) sluggish peristalsis of the duodenum; (3) modification of the folding of the mucous membrane of the duodenum; (4) residue within the stomach and duodenum at the four-hour examination; (5) tenderness on pressure at the site of the pancreas; (6) filling of the ampulla of Vater with the opaque meal.

The author discusses in detail especially the filling of the ampulla of Vater by the barium meal as an important sign in the roentgen diagnosis of pancreatic affections. Case was the first to call attention to the filling of the ampulla of Vater during the barium meal examination. However in his cases the condition might well have been that of duodenal diverticulum. The case described by Akerlund was more probably that of a filled ampulla of Vater. In endeavoring to differentiate between a barium filled ampulla of Vater and a duodenal diverticulum, Lindblom gives the following signs as more or less characteristic for the filling of the ampulla of Vater: (1) The anatomical situation of the ampulla of Vater which is at the internal aspect of the middle third of the descending portion of the duodenum. (2) The contractility. Since the ampulla of Vater is richly provided with muscles, serial roentgenograms will reveal a variation in the form of the contrast shadow due to changes of contractility. This is not present in cases of diverticula. (3) The form. In addition to the change in contour due to contractility one often observes a bipartite appearance due to the confluence of the common duct and Wirsung's canal. (4) The rate of evacuation. The ampulla of Vater evacuates spontaneously as a rule soon after the evacuation of the stomach and duodenum. Therefore a residue following the evacuation of the stomach and duodenum indicates, rather, the presence of a diverticulum.

On the basis of the above signs it is possible in a majority of the cases to differentiate between the filling of the ampulla of Vater and a duodenal diverticulum. The author presents a case where this differentiation, however, was impossible.—*T. Leucutia.*

Lysholm, Erik. Contribution to the technique of projection in roentgenological examination of pars petrosa. *Acta radiol.*, 1928, ix, 54–64.

The author describes eleven positions for the roentgenologic visualization of the different parts of the petrous bone. Each position is described in detail and is illustrated by means of schematic drawings. The advantage of such a procedure in the differential diagnosis of tumors is discussed.—*T. Leucutia.*

Mayer, Ernst G. The roentgen findings in retrobulbar affections of obscure etiology and their differential diagnostic value. *Acta radiol.*, 1928, ix, 383–398.

Roentgenograms should be taken in all cases of retrobulbar affections of obscure etiology. The roentgenogram should include in addition to the orbit the accessory sinuses, as well as the middle fossa. An obscuration of the accessory sinuses on the diseased side does not mean that the focus of the intra- or retro-orbital process is in the sinus since an involvement of the accessory sinuses is often observed secondary to a retrobulbar lesion. The following criteria should be considered from the point of view of differential diagnosis. Extensive and intensive clouding of the accessory sinuses with slight or no changes of the orbital walls indicates a primary lesion of the accessory sinuses. A slight clouding of the accessory

sinuses with a marked lesion of the orbital walls points to an intra-orbital localization of the process. Likewise a slight change in the lamina papyracea with localized clouding of the ethmoidal cells indicates the possibility of an intra-orbital process.

Benign intra-orbital tumors, as a rule, produce no pathological changes on the roentgenogram.

A one-sided slight or medium clouding of the accessory sinuses might be caused by a retro-orbital process, therefore in such cases the condition of the middle fossa should always be investigated. Bone erosions and signs of intracranial pressure as a rule indicate tumor. If the process is circumscribed and extends only over a small zone of the affected side, the possibility of localized endocranial pressure should be considered..—*T. Leucutia.*

MEZZARI, A. Tuberculosis of the tuberosity of the tibia. *Radiol. med.*, Dec., 1928, xv, 1209–1213.

The processes of bone to which the tendons are attached are particularly subject to tuberculosis because of the functional demands made on them and because they are embryologically a part of the epiphysis which is a very vascular region.

A case is described in a young man of twenty-two who had had an amputation of the right femur for tuberculosis of the knee-joint and a disarticulation of the left thumb for spina ventosa. About six months later he had pain in the left knee followed by a fluctuating swelling the size of a nut; he said there had been no trauma. The swelling was at the site of the tuberosity of the tibia which was painful on pressure and had crater-like edges. The left knee was in good position and not enlarged. Flexion was slightly limited; active extension good. Aspiration gave 25 c.c. tuberculous pus. In a few months a fistula developed; treatment was with a closed plaster cast and heliotherapy. The tuberosity of the tibia finally formed a sequestrum and was removed surgically. Recovery after two months with good function of the knee and with the fistula completely closed. A series of roentgenograms is given showing the progress of the process from its beginning as a spot of atrophy in the tuberosity of the tibia, through sequestration of the tuberosity, the formation of a large cavity inside the sequestrum and final repair leaving only a niche the shape of an almond. Tuberculosis of the tuberosity as a part of a general disease of the joint is not unusual but such cases of tuberculosis of the tuberosity alone are very rare.

MOGGI, B. Roentgen picture of eleopathy. *Radiol. med.*, Dec., 1928, xv, 1225–1226.

A man aged fifty-four had tuberculous coxitis about four years ago for which he was given medical and heliotherapeutic treatment and the coxofemoral joint was immobilized. A roentgen examination was made about two years ago. Last June he returned for another roentgen examination. This examination showed many spots which were very opaque to roentgen rays occupying all the roentgen field. The author was surprised by this as there had been no such spots on the previous examination. Many little nodules could be felt on the buttocks and flanks which the patient said were painful when he sat down. They had apparently resulted from a number of injections of an oily solution of iodide and guaiacol which the patient had been given. These little fatty tumors result from the diffusion along the lymphatics of the oil from such injections and have been seen after injections of camphorated oil. The spots in this case were innumerable and small, showing that the solution had been broken up and distributed along the lymphatics; these droplets of oil act as foreign bodies and cause a slow inflammation leading to the formation of new connective tissue which gradually encapsulates the droplets, forming the little tumors.

ÖHMAN, RUNAR C. Contribution to the knowledge of the roentgenological appearance of silicosis. *Acta radiol.*, 1928, ix, 266–288.

Between 1922 and 1927 the author examined about 100 cases of emigrants who had returned home from different mining districts such as the South African gold mines (Transvaal) and North American mineral mines (Nevada, Idaho, Minnesota, Montana, Utah, Colorado and other mining districts). Of the 100 cases, 31 were deducted, 12 since the roentgenogram was negative and 19 because of other complications such as emphysema, heart conditions and tuberculosis. The remaining 69 cases proved to be positive for silicosis. From the roentgenological aspect these cases are classed into four groups: (1) Enlarged and increased hilus shadow—22 cases. The most characteristic feature of this condition is the often sharply defined enlargement of the bronchial lymph nodes. (2) Increased linear markings and very slight mottling of the lungs—17 cases. In this group a felt-like structure of the lung is observed in instances with very early mottling. The process is most pronounced in the middle zone of the lungs and as a rule is more apparent on the right side. (3) Slight mottled

appearance—13 cases. This group is characterized by intensive, sharply limited densities from millet to linseed size; in rarer cases pea size. The opacities observed are principally in the middle and lower portions of the lungs, the apices remaining free. (4) Coarse mottling (massive shadows)—17 cases. This group shows large massive densities scattered over both lung fields, with the exception of the apices. This is often intermingled with densities of stages 2 and 3.

There is no clear demarcation between the different groups.

The following points are important from the point of view of differential diagnosis: The linear markings in silicosis are sharp and well organized, while in peribronchial tuberculosis they appear more diffuse and in the form of peribronchial infiltration. In the cases of groups 2 and 3 sometimes a differentiation from miliary tuberculosis is very difficult. The absence of changes in the apices is suggestive of silicosis. It has to be borne in mind that in some instances silicosis may be associated with tuberculosis. Here the clinical signs will be of a greater aid in the differentiation.—*T. Leucutia.*

Podesta, V. Pneumocystoroentgenography in the study of calcified tumors of the uterus. *Radiol. med.*, Dec., 1928, xv, 1173–1179.

A case is described in a peasant woman sixty-four years of age. She had had frequent and copious metrorrhagia since the age of eighteen and a physician at that time had made a diagnosis of fibroma of the uterus. But she had been married at twenty-five and had given birth at term to three living boys without any special difficulty in labor. At about the age of forty she had had abdominal pain and a physician had diagnosed fibroma of the uterus and advised operation which she had refused as the tumor was not giving her much trouble. Recently she had hematuria and a physician sent her to the author for roentgen examination for urinary calculus. Ordinary roentgen examination did not show any calculus of the kidneys or ureters but did show a dark mass in the pelvis which might have been a large calculus of the bladder; it looked like a homogeneous calcified mass, and was the size of a large mandarin. To make sure of the diagnosis he made a pneumocystoroentgenographic examination and found the bladder free of stone; the calcified mass was in the uterus and had probably resulted from calcification of the fibroma which the patient had had since her youth.

The author emphasizes the importance of pneumocystoroentgenography in the differentiation of such tumors from calculi or tumors of the bladder. Both simple pneumocystoroentgenography and the combined method (opaque medium and gas) are excellent methods in the differentiation of such tumors of the uterus from pathological conditions of similar appearance in the bladder or elsewhere in the pelvis.

Renander, Axel. The value of röntgen diagnostics in cancer coli. *Acta radiol.*, 1928, ix, 213–221.

The author has collected 63 cases of cancer of the colon examined between 1912 and 1926 at the Serafimerlasarettet. In all cases the diagnosis was confirmed either by operation or post-mortem examination. Of the 63 cases, 53 were true cancers of the colon, 2 represented extrinsic tumors encroaching on the colon, and in 8 the diagnosis of cancer of the colon was made by the roentgenologic method but no cancer could be found at operation or post mortem.

The value of the roentgen examination was determined in these cases as compared with the value of clinical findings. It was found that the roentgen examination was positive in 86 per cent of the cases, the clinical examination being positive in only 56 per cent. If only the operable cases are considered the roentgen examination led to a positive diagnosis in 91 per cent of the cases, the clinical examination in only 48 per cent. Of the inoperable cases alone the roentgen examination was positive in 82 per cent of the cases, the clinical method in 70 per cent. The conclusion is therefore reached that the roentgen examination is of greatest value in the operable cases. By using both the roentgen and the clinical examination one may increase the number of positive diagnoses over either method alone.—*T. Leucutia.*

Renander, Axel. Bone changes in a case of cutis verticis gyrata. *Acta radiol.*, 1928, ix, 399–409.

The author describes a case of cutis verticis gyrata with extensive bone changes. Roentgenograms taken of practically the entire skeleton show changes similar to those observed in acromegaly. Thus there is a marked cortical hyperplasia of the bones of the upper and lower extremities with sclerotic periosteal and endosteal deposits. There is a thickening of the bones of the skull with a very marked enlargement of all the accessory sinuses and prominence of the malar bones and of the jaw. The condition therefore appears to be one of endocranial disturbance. The marked sclerosis might be explained on the basis of a "toxic osteoperiostitis ossificans" (Sternberg).

In surveying the literature there is only one case of cutis verticis gyrata described (Sisson) where roentgenograms were taken. In that case the changes were described as slight periosteal deposits at the distal ends of the radius and ulna.—*T. Leucutia.*

SGALITZER, MAX. Myelography with descending and ascending lipiodol. *Acta radiol.*, 1928, ix, 136–146.

The author discusses the clinical value of ascending and descending lipiodol in the diagnosis of spinal cord tumors. Myelography was applied in 17 cases of true and suspected spinal cord tumors and it was found that in 9 of the cases the ascending lipiodol produced rather uncomfortable symptoms. Seven of the cases showed headache, elevation of temperature and root pains, while in 2 others there was also stiffness of the neck and fever for a period of thirty-six hours. All symptoms subsided after a few days. One arrives therefore at the conclusion that the injection of ascending lipiodol is associated with more uncomfortable clinical symptoms than is the case with the descending lipiodol. For this reason, Sicard and Forestier now apply descending lipiodol by the lumbar route and place the patients in a 60° Trendelenburg position for a period of twenty minutes following the injection in cases where, formerly, ascending lipiodol would have been used. Sgalitzer, however, thinks that the use of the ascending lipiodol should not be abandoned and in order to prevent the severe clinical symptomatology produced by the injection he advises the following procedure: First the descending lipiodol is introduced in the usual way. The patient is kept in an elevated position in bed and roentgenograms are taken at intervals of four, twenty-four and forty-eight hours. Should this method prove insufficient the ascending lipiodol is injected not sooner than forty-eight hours and, as a rule within four to five days, by the usual lumbar puncture. Only 2 c.c. of lipiodol (a solution of metallic iodine in pure olive oil) is injected. The patient is then placed in bed in an elevated dorsal position and roentgenograms are taken at four, twenty-four and forty-eight hour periods. If no symptoms appear by the end of the fourth day the patient may get up. It is very important that previous to the injection the lipiodol preparation should be tested out. This is done by simply putting a drop in a saline solution. The lipiodol should immediately rise to the surface and float.

Since ascending lipiodol produces more severe symptoms in patients with pathological lesions, it is advised that a lipiodol injection be made only in cases where the diagnosis cannot be made otherwise. A close co-operation between neurologist and roentgenologist is of prime importance.—*T. Leucutia.*

ŠIMON, JOSEF. Esophageal diverticulosis and diaphragmatic hernia through the esophageal hiatus. *Acta radiol.*, 1928, ix, 296–301.

A case of diverticulosis of the esophagus associated with a diaphragmatic hernia through the esophageal hiatus is described in a man aged forty. The association of the two lesions indicates that the condition most probably is that of a congenital malformation. Only a few such cases are described in the literature.—*T. Leucutia.*

ROENTGEN AND RADIUM THERAPY

BARDACHZI, FRANZ. Roentgen treatment of inflammatory complications of scarlet fever. *Strahlentherapie*, 1928, xxviii, 805–807.

The author has used weak roentgen irradiation in 10 cases of scarlatinal cervical lymphadenitis; in 4 of these cases the swelling of the glands developed soon after the beginning of the disease, in the others later. In all of these cases there was enormous enlargement of the glands, with fever, which did not yield to the usual treatment. In 9 of the irradiated cases the result was excellent; in one of the cases the effect was immediate, in the others gradual. In 2 cases the irradiation had to be repeated after a few days. In all these cases the pain was controlled and the general condition improved. In one case suppuration quickly followed the irradiation and after incision there was rapid healing. The treatment failed in only one case in a five year old child who had recurrence with severe angina, lymphadenitis, nephritis and signs of sepsis. On irradiation the swelling of the glands receded but the child died of sepsis.

Weak roentgen irradiation was also used in a case of mastoiditis and sinus thrombosis and in one of severe suppuration of the ethmoid cells. In both cases operation was performed, so though the patients recovered in both these cases of severe sepsis it is impossible to say how much of the effect was due to the roentgen rays, but the author has the impression that they had a good effect. In another case of pleurisy with high fever in a relapse of scarlet fever irradiation brought about rapid improvement.

In all severe cases of complications of scarlet fever which do not yield to the usual treatment or which progress so rapidly as to cause anxiety the author recommends the use of roentgen treatment.

Bolaffio, M. Experience with roentgen treatment of carcinoma of the cervix. *Strahlentherapie*, 1928, xxix, 453–463.

In October, 1920, roentgen treatment was begun at the author's clinic. Before that time they had been using mesothorium. They first used the Erlanger method of roentgen treatment, then the Dessauer-Warnekros method, then a method of their own in which 5 fields 12 × 10 cm. were irradiated, but the results were not much different. In 1922 they adopted a method of irradiating 3 fields at intervals of six or seven days, giving half a skin erythema dose at each treatment. The results with this method were not particularly better as to cure but there was less roentgen sickness and no more cases of roentgen cachexia or ileus. From 1922 on they began to combine roentgen and radium treatment. In many cases they applied 50 mg. radium element for thirty-six to forty-eight hours, either once or twice after an interval of five or six days, making a total of 1200–2400 mg-hr., followed after a week by the first roentgen treatment.

Tables are given showing the details of the results. Counting operable, borderline and inoperable cases all together there was a total of 7.6 per cent cures after more than six years' observation; 8.6 per cent after more than five years; 11.3 per cent after more than four years; 15.2 per cent after more than three years, and 19.8 per cent after more than two years. The material shows that with combined roentgen and radium treatment the results are about four times as good as with roentgen treatment alone and about twice as good as with radium alone.

When the percentage figures in carcinoma of the cervix are followed up for a number of years after roentgen treatment the decrease in the number of cured cases is about the same every year; it does not stop with the fifth year, still less with third. In operated cases there is a considerable loss the first year but after that the curve remains at about the same level. That is to say, if an operated case is going to recur it does so quickly; if all the carcinoma tissue has really been removed it does not recur. But roentgen treatment never kills all the cancer cells and the cancer may recur after any length of time. So roentgen treatment is only a palliative, though it is the best one available.

Borak, J. A new method of treating senile pruritus. *Strahlentherapie*, 1928, xxix, 245–254.

Senile pruritus is caused by a disturbance of metabolism, consisting of an enormous increase in metabolism and an abnormal increase in the accumulation of products of albumin catabolism in the tissues as a result of it. These abnormal products sensitize the nerve endings and this causes pruritus just as products of metabolism containing carbohydrate cause pruritus in diabetes. Just as the disturbance of metabolism that causes pruritus in diabetes can be overcome by insulin that which causes essential senile pruritus can be overcome by roentgen irradiation of the hypophysis or thyroid. The author has used this treatment in 10 cases in which various other treatments had been used without success. Eight of them were greatly improved within a week after the irradiation; the hypophysis was irradiated in 7 and the thyroid in one. They have remained well during an observation time of two and a half years. Two cases in young persons with a generalized pruritus were successfully treated in the same way. But the method did not prove successful in most cases of localized pruritus, pruritus of the vulva, anus, back, face, etc. Local methods of treatment must be used in the localized forms of pruritus.

Brunauer, Stefan. Radium treatment of warts. *Strahlentherapie*, 1928, xxix, 255–262.

Two cases are described, one of multiple verruca vulgaris of the soles of the feet and the other of multiple small papillomas of the face and scalp that were cured by radium. The radium was applied in the form of a radium paste rubbed on linen cloth, forming a compress which could be accurately adapted to the surface to be treated; a surface of 100 sq. cm. contained about a milligram of radium bromide. With this method not only the hard beta and gamma rays but also the soft beta rays and a considerable part of the alpha rays are utilized. The method is best adapted for cases of multiple warts or ones so localized that they cannot be treated by the ordinary methods. For cases with single large warts or only a few it would perhaps be better to use carbon dioxide snow, electrolysis, cauterization or the usual methods of application of radium in the form of radium carriers or tubes.

Buchholz, Karl. Treatment of carcinoma of the breast. *Strahlentherapie*, 1928, xxix, 698–706.

From Jan. 1, 1906 to March 31, 1924, the author's clinic has treated 384 patients with carcinoma of the breast; 358 of these were operated on. From this material it seems to him that prophylactic after-irradiation is justified in cancer of the breast. The change in technique in the last period of roentgen treatment, consisting of increase in the dosage and hardness of the rays led to poorer results.

From his experience he does not believe the poorer results were caused by the increased hardness but by the increased amount of rays. So he believes that in carcinoma of the breast the roentgen treatment supplementing operative treatment should be with frequent medium-sized doses. It remains for the future to show the value of the tangenital irradiation recommended by Holfelder; at present there has not been enough experience with the technique and a long enough time has not passed to judge the results. In addition to roentgen treatment radium treatment proved valuable, particularly in treating local recurrence.

Bucky, Gustav. Is Bucky's borderline ray therapy completely free of danger? *Strahlentherapie*, 1928, xxviii, 629–632.

This is in reply to criticisms of Bucky's borderline ray therapy made by Martenstein. Martenstein's objections are based on physical measurements, histological examinations and hypotheses and conclusions from analogy. Bucky discusses Martenstein's methods of measurement and concludes that they are not reliable. With regard to the histological findings he quotes Martenstein in describing a case that had been given 6 times the erythema dose of borderline rays as saying that the changes produced were not extreme but resembled those produced by low intensities of roentgen or radium rays. But it is known that twice the erythema dose of roentgen rays causes necroses and severe injury and if 6 times the erythema dose of borderline rays only causes slight injury it shows that they are at least much less dangerous than roentgen rays.

Martenstein says that Bucky has decreased the tension and must have done so because he had seen cases of late injury. Bucky replies that the real cause of his decrease of tension was the improvement in tube technique with better Lindemann windows which made it possible to get therapeutic results with lower tensions. He has only had two cases of late injury, one of telangiectasis in a case of psoriasis and one of necrotic acne in which irradiation was given on a skin denuded of epidermis and left a thinned and depigmented area.

Of course the technique and indications of the new method are not entirely worked out and he hopes his work will lead other authors to publish their results.

Martenstein, Hans. Reply to Bucky's defense of his borderline rays. *Strahlentherapie*, 1928, xxviii, 633–636.

In reply to Bucky's criticism of his method of measurement, the author says he has never claimed that it is absolutely exact. In fact he has published a discussion of the sources of error in measuring with modified Kienböck's strips. His object was not to give an absolutely exact physical method of measurement of absorption but to determine whether the deeper layers of the skin are acted on by very large amounts of rays. He found that Bucky's chief requirement that the restitution layer of the epidermis be not destroyed was not fulfilled. He shows by citations from the literature that the basal layer of the skin is injured as much as by roentgen rays. He thinks that his histological results therefore are less hypothetical than Bucky finds them. He cites passages from Bucky's own work giving a warning against the use of too large doses and concludes that Bucky's decrease of the tensions used must be due to the fact that he has seen late injuries which he is trying to prevent.

Dautwitz, Fritz. Radium irradiation of skin cancer. *Strahlentherapie*, 1928, xxix, 634–677.

Dautwitz reports 186 cases of cancer of the skin treated with radium. In 108 of the cases no other treatment had been given except with salves or caustics. In the other 78 surgical, roentgen or radium treatment had been given but the results had not been satisfactory. In all except 19 of the cases the lesions were on the face. In 4 they were on the trunk, in 11 on the limbs and in 3 on the scalp. The lymph glands were involved in 34 cases. Dautwitz has designed a plate apparatus by means of which external irradiation was given. He uses beta rays chiefly even in superficial ulcers. He does not believe that the beta rays act as a pure caustic, destroying both diseased and healthy tissue; the scars in his cases were faultless from the cosmetic point of view. He has not seen any untreated, ulcerated skin cancers that did not react to beta rays. The success of radium treatment in skin cancers seems to depend on whether they are acted on merely by electromagnetic rays or chiefly by corpuscular rays. He gives two to eight treatments with fractional doses, each from four to eight hours in length, with intervals of twelve to thirty-six hours between them. In the group of cases that had not been given previous treatment 70.4 per cent were cured and remain so after from five to fifteen years. Among the group that had been treated previously by irradiation or surgery 50 per cent were cured for over three years and 19.2 per cent for five to fourteen years. Brief histories of 14 cases are given and photographs before and after treatment.

Epstein, R. Treatment of chronic leucemia. *Strahlentherapie*, 1928, xxviii, 799–804.

There is a great deal of difference of opinion in the literature as to the value of roentgen treatment in chronic leucemia. The author believes that the doses recommended in the literature are unnecessarily high and even dangerous. The dosage should be determined according to the roentgen sensitiveness of the patient. In analyzing his cases he finds four groups with reference to roentgen sensitiveness: (1) Cases which react well for a long time to moderate and small doses; (2) cases in which the dose must be increased after a longer or shorter interval; (3) cases which pass into a stage refractory to rays or can no longer be irradiated as a result of cachexia; (4) cases in which the blood is affected favorably but the enlargement of the spleen reacts little or not at all to irradiation. Cases illustrative of each group are described.

There is also difference of opinion as to the value of irradiation of the bones and liver. The author believes there are cases which can be cured by irradiation of the spleen alone, others in which irradiation of the bones and liver is indispensable; in the latter cases the spleen dose can be decreased. He gives an illustrative case showing the excellent effect of irradiation of the liver. Care must be exercised in irradiating the liver as even small doses sometimes cause severe roentgen sickness.

Another disputed point is whether an attempt should be made to bring the leucocyte count back entirely to normal. The author concludes that it is desirable and an attempt should be made to accomplish it if this can be done with small doses. But a renewed irradiation should not be given until the effect of the preceding one has passed off, and if the leucocyte count shows a tendency to remain above normal it should not be forced down by too large doses.

Eymer, H. International co-operation in the question of radium therapy of cancer of the cervix. *Strahlentherapie*, 1928, xxix, 464–468.

The establishment of a Cancer Commission of the Hygiene Section of the League of Nations to deal with the treatment of cancer is a valuable step in the direction of international co-operation in such problems. The Cancer Commission cannot of course undertake treatment but the author believes much could be accomplished by collecting really reliable statistics in all countries and turning them over to the Cancer Commission so that uniform methods might be establishd everywhere. Statistics in regard to radium treatment in order to be of any value should be on cases treated only with radium by physicians who have had a large experience in this field extending over a period of at least five years. They should report whether radium emanation or radium salt was used and how much, how the preparations were distributed inside or outside the genital canal, what sort of filtration was used, how the neighboring organs were protected, how the apparatus was fastened, what was the total length of the treatments and the total dosage, how many treatments were given and at what intervals, what preliminary treatment was given if any and what after-treatment. Reports of the histological nature of the carcinoma should also be given. Such material as this in the hands of an international commission would be of great value.

Fried, Carl. The roentgen irradiation of acute and subacute purulent inflammations. *Acta radiol.*, 1928, ix, 109–116.

The present work of Fried includes a material of 1500 cases. An average of 75 to 80 per cent good results were obtained. All forms of infections have been subjected to irradiation. In some instances the healing was rapid and spontaneous; in other instances the process localized and it came to abscess formation. The abscess was incised and then the healing was rapid. The cosmetic results were very satisfactory. The different forms of inflammations are considered in detail.

Furuncles. Especial attention is paid to the furunculosis of infants. Here two to three irradiations at intervals of eight days are given by using two large portals of entry, one from the front and one from the back, with a dose of 80 to 120 R per field. The irradiation of the two portals is carried out on consecutive days.

Furunculosis of the sweat glands of the axilla. The results are excellent. The dose is 160 R which is sometimes repeated within eight days. In prolonged cases a third or fourth irradiation may be given, within one to three week intervals. Sometimes an incision or simple puncture of the abscess formed is necessary.

Furuncles and phlegmons of the face. The results are good. The dose is 160 R. Here especial attention has to be paid to the adjacent lymph nodes. Fried also advises roentgen therapy for dental conditions such as periodontitis, periostitis and pyorrhea. In such cases a combination with surgical procedures is sometimes necessary.

Phlegmons of the neck and extremities. The course of these lesions is shortened by irradiation. However, when there is evidence

of pus formation an immediate surgical intervention should be undertaken. This especially applies to the phlegmons of the tendon sheaths. The irradiation usually includes within one field practically the entire diseased area. If this is impossible, as for example in cases of lymphangitic complications, a second field should be reserved for the affected lymph nodes. In this case it is well to reduce the dose to 120 R.

Paronychia. In most cases a local irradiation is sufficient; in others the adjacent lymph nodes have to be included in the irradiation. Lymphangitis usually disappears within twenty-four hours following treatment.

Chronic recurrent anginas, phlegmonous anginas and Vincent's angina are also favorably influenced by irradiation. A dose of 160 R over the region of the tonsils is given through unilateral or bilateral fields of entry.

Abscesses of soft parts. In all abscesses the irradiation should be carried out following surgical intervention. The results with regard to granulation are sometimes miraculous. Even in appendicial abscesses and pyosalpinx an irradiation following the operative procedure should be attempted. Here it is best to use a single large field over the lower abdomen by giving 160 R at 30 cm. distance.

Erysipelas. The results are so satisfactory that roentgen therapy in erysipelas has become the method of choice. The headaches and the pressure symptoms disappear within twenty-four to forty-eight hours. From this moment the erysipelas shows a tendency towards demarcation and a rapid clinical healing. It is best to apply here a dose of 200 R and if necessary to repeat within eight days. If several portals of entry have to be used with cross firing, the dose should be reduced to 120 to 160 R per field. Erysipeloids should be treated in the same way as erysipelas.

Postoperative pneumonias. The results here are miraculous. One can safely say that the mortality from postoperative pneumonias has been reduced to zero. The improvement following the roentgen therapy is immediate. A few hours after the roentgen therapy the patients already feel better and within twelve to twenty-four hours the fever disappears; within forty-eight to sixty hours there is lysis. The irradiation is carried out through a posterior field of entry from a 50 cm. distance. The dose is 120 R; in very severe cases and in children 80 to 100 R; in infants 50 to 60 R (here 30 cm. distance). No results were obtained in pleuritis and empyema.

Inflammation of the glands. The irradiation of the great glands (mamma, parotids) should be carried out with a somewhat higher dose (200 R); also chronic cases should be treated. In orchitis, epididymitis, and strumitis, a dose of 120 R should be given; in children and younger individuals 80 to 100 R is used.

Acute osteomyelitis. In acute forms no results were obtained; in the chronic forms roentgen therapy is sometimes of value in combination with surgery.

Gynecologic infections. The pure parametritis shows 100 per cent results (Wagner). Even great infiltrations disappear within a few days. Also salpingitis, peri- and endometritis, especially following abortion as well as the infiltrations of the Douglas space, are suited for roentgen therapy. Following the localization of the process an incision through the vagina or sometimes only puncture through the vagina will lead to results. Peritonitis and sepsis cases should also be treated by roentgen rays. In some instances results were obtained. In all these cases the entire lower abdomen is irradiated through a large field from a 50 cm. distance, applying a dose of 160 R. The treatment can be repeated within eight to ten days.

Pordes and Fried have recently reported over 50 cases of inflammations of the eye (iritis, scleritis, cyclitis keratitis, chlorioiditis and sympathetic ophthalmia) treated by roentgen rays with very satisfactory results. Their dose is 1 to 2 H (50 to 10[illegible] R), three times within eight days.

Fried describes his own technique as follows: 0.5 mm. Zn plus 1 mm. Al as filters; 100 to 140 kv., 8 ma. The doses are only superficial. In conclusion Fried advises that irradiation be carried out in all infectious cases at the earliest possible moment.—*T. Leucutia.*

Fuhs, H., and Konrad, J. Roentgen therapy of the skin with very small doses. *Strahlentherapie*, 1928, xxix, 230–240.

Thedering recommended indirect treatment of skin diseases by irradiating the spleen with very small doses of rays. The authors' experiments in testing this method agreed with their results in irradiating endocrine glands and the spinal cord and medulla with very small doses (2 to 3 H through 4 mm. aluminum or 0.3 to 0.5 mm. zinc). They have not had definite therapeutic results either from irradiation of the thymus for psoriasis or sclerodermia, the hypophysis for alopecia areata and sclerodermia, the thyroid and thymus for sclerodermia, the thyroid and ovaries for eczema or the spinal column (sympathetic) for eczema, neurodermatitis, pruritus, lichen ruber planus, etc.

Therefore from their experience so far they

do not believe in the effectiveness of indirect irradiation of skin diseases by way of the different endocrine glands, spleen and sympathetic.

Füllsack, Hans. Experience with E. G. Mayer's grape sugar treatment in association with roentgen irradiation of malignant tumors. *Strahlentherapie*, 1928, xxAiii, 795–798.

E. G. Mayer attempted to make tumors more sensitive by the injection of grape sugar and then irradiating them; ini noperable cases of carcinoma he gave 10 c.c. of a 10–15 per cent grape sugar solution. Often he continued this treatment after the irradiation. He found that the results were much better after this combined treatment than after irradiation alone. Holzknecht confirmed these good results. The author tested these results in 35 cases, all of them inoperable; 14 were carcinomas of the uterus with severe disease of the parametria, 7 carcinomas of the breast with metastases and recurrence, 6 carcinomas located elsewhere, 5 cases of severe sarcomatosis and 3 cases of malignant tumors of the throat, the exact histological nature of which was not determined. There was disappearance of the tumor in 3 cases, considerable improvement in 3, 5 remained stationary, 5 grew worse and 19 died, 11 after temporary improvement and 8 without any improvement. The author cannot say whether the grape sugar solution had a good effect on roentgen sickness as he has rarely seen it in his cases even without the sugar treatment. The cases show that the treatment is not very effective and the hopes aroused by the reports of Mayer and Holzknecht are exaggerated.

Grauer, S. Roentgen therapy of arthritis of the shoulder joint. *Strahlentherapie*, 1928, xxix, 172–179.

Six cases of roentgen treatment of arthritis of the shoulder joint in patients from forty to eighty-one years of age are described. The joints were irradiated at intervals of seven days alternately in the anteroposterior and posteroanterior directions; three surface doses of 7 Holzknecht units each were given. A field around the joint measuring at least 20 × 20 cm. was irradiated and the distance from the focus to the skin was 30 cm. The boundary wave length of the irradiation was 0.1 Å, filtered through 0.36 mm. zinc and 2 mm. aluminum. With this irradiation erythema appears in about fourteen days with a surface dose of 16 H.

This is one of the fields in which roentgen treatment is most successful. Nearly all the cases react well to the irradiation. The more of an inflammatory component there is in the arthritis, the quicker and more certain the effect of the rays. The cure is permanent.

Grauer, Sepp. Experience in the roentgen treatment of gonorrheal arthritis. *Strahlentherapie*, 1928, xxix, 303–310.

Six cases are described which show that roentgen treatment is very successful in gonorrheal arthritis. It is particularly well adapted for the acute and subacute forms of the disease. The action is rapid and the results permanent. Roentgen therapy can be combined with the methods of treatment previously used.

The effect of the rays cannot be due to a direct bactericidal action on the gonococci. Experiments have shown that cultures of gonococci can be killed by irradiation, but the dose required is far above the dose tolerated by the skin. The action of the rays seems to consist of a change in the physico-chemical nature of the irradiated tissue which creates unfavorable living conditions for the gonococci. In the polyarticular forms there is an improvement in all the joints when only one is irradiated, though less in degree than in the joint that is irradiated directly; this indicates that the action of the rays is indirect.

In the author's cases the joints were irradiated at intervals of from several days to a week, three to four surface doses of 3–4 H being given on a field 15 × 15 cm. in size with a focus skin distance of 30 cm. for the smaller joints and 40 cm. for the larger ones; filtration 0.36 mm. zinc and 2 mm. aluminum, wave length 0.1 Å. Not less than 25 per cent of the skin erythema dose should be given per field for with less than that the therapeutic effect is less.

Haas, Ludwig. Roentgen hyposensitiveness of the skin. *Strahlentherapie*, 1928, xxix, 608–611.

A case of hyperidrosis is described in a girl aged twenty in which the author gave several times an erythema dose without any unpleasant reaction and there was no therapeutic effect until this large dose was given. The skin of this patient was examined for sensitiveness to other stimuli. The reactions to adrenalin and dermography were markedly decreased, those to quartz light and the galvanic current normal, those to heat and mustard increased. Pronounced hyposensitiveness of the skin to roentgen rays was also found in 3 other cases of hyperidrosis. The practical significance of this hyposensitiveness is that it may cause failure of treatment. The decreased sensitiveness is evidently not due to the hyperidrosis for there are cases of that disease in which

sensitiveness is normal. Hyperidrosis is the only disease in which the author has risked such large dosage and so discovered the hyposensitiveness. Possibly the hyposensitiveness is due to poor blood supply to the skin, which was found in older tests of sensitiveness of the adrenalinized skin. The condition of contractility of the blood vessels may play a part in it and this in turn may be caused by the condition of innervation.

Harris, William, and Kean, Albert. Therapeutic abortion with roentgen rays. *Strahlentherapie*, 1928, xxviii, 637–638.

The authors agree with Fürst that therapeutic roentgen abortion is indicated only in cases in which in addition to abortion permanent sterility is indicated. The indications must be established by a trained specialist and permission must be obtained to perform surgical abortion if roentgen abortion fails. But they disagree with Fürst to the extent that they believe that in indicated cases therapeutic roentgen abortion is the method of choice, as in skilled hands it is reliable and almost entirely free of danger. From their experience they believe that Fürst's fear of bits of placenta being retained is exaggerated and think it can be prevented by homogeneous irradiation. Roentgen abortion should be performed only by a skilled roentgenologist with a reliable apparatus and in a hospital.

Heiner, Max. Radium treatment, in combination with a special diet, in the treatment of certain forms of metabolic disease. *Strahlentherapie*, 1928, xxviii, 788–794.

A considerable increase of blood sugar was found in a large number of patients with chronic neuralgias and chronic diseases of the joints and skin, though they had no glycosuria. This seemed to indicate that these diseases were due to a primary endogenous disturbance of metabolism and they were treated by radium in association with a special diet which contained 57 gm. albumin, 72 gm. carbohydrate and unlimited amounts of fat in the form of butter. Some of the patients were given radium baths alone, some baths and the drinking of water containing radium, some baths and radium injections and some baths and radium irradiations. In most of the cases there was a decrease of about 25 per cent in the original blood sugar value on radium treatment; the fall was greater than that only in cases in which quite large doses of radium irradiation or radium injection were given. With the decrease in blood sugar there was an improvement in the subjective and objective symptoms, which seems to indicate that the diseases were due to disturbance of metabolism and the blood sugar was a measure of the degree and nature of the disturbance. The blood sugar values in these cases were brought down completely to normal only in cases in which the diet was given in conjunction with the radium treatment. The results in these cases show that the biological action of radium is not solely local but that it produces biochemical actions in the whole organism. Relatively weak injections of radium chloride into the muscles or joint capsule brought about a much more rapid and pronounced fall in blood sugar than a considerably larger dose of radium given by irradiation. A comparison between groups with the same clinical symptoms, one of which had increased blood sugar and the other normal blood sugar showed that radium had better effects in the former group.

Herrnheiser, G., and Braun, G. Roentgen treatment of tuberculosis of the eyes. *Strahlentherapie*, 1928, xxviii, 770–778.

The literature is reviewed showing that the results of roentgen treatment are very good in tuberculosis of the anterior segment of the eyeball. A number of cases from the authors' practice are described briefly and confirm these results. But in contrast with the experience of other authors they also had decidedly good results in 9 cases of tuberculous choroiditis. Processes of a productive nature were generally cured quicker than ones in which the changes were exudative. In the former there may be complete restoration to normal. The treatment is given in small doses of a moderately hard, moderately filtered radiation at relatively short intervals.

Heyman, J. Radiant or operative treatment of cancer of the uterus. *Strahlentherapie*, 1928, xxix, 407–452.

The author has made an effort to collect all the complete statistics in the world literature on the results of the radical operation for cancer of the cervix of the uterus. These statistics, which represent the end results of operative treatment, have been revised to uniform standards and an effort made to determine from them just what is accomplished by the radical operation. The average values for the absolute results of operative treatment in the material published so far when strictly tested give at most 20.2 per cent cures. The statistics of the Radium Institute (Stockholm) include about 500 cases of carcinoma of the cervix treated primarily with radium and 41 not treated. The absolute result for these cases, strictly tested, is at least 20.7 per cent cures. The number of operable cases in the surgical

material was 58.6 per cent, while in the radium material it was only 26.6 per cent. Taking into consideration this difference in the material, it seems justifiable to conclude that radiotherapy, as used in the Radium Institute, is better in absolute results than operative treatment in cancer of the cervix. The material of irradiated operable cases alone is too small to permit of comparison with the operative results. But the figures available so far do not indicate that any more can be accomplished by surgery in these cases than by irradiation.

The figures published so far in regard to operative treatment and irradiation of cancer of the body of the uterus are too small to permit of final conclusions. The statistics for operation show that the average absolute result is 42.8 per cent, and the result of surgical treatment in operable cases alone is on an average 58.8 per cent. The statistics of the Radium Institute include 46 cases with an absolute result of 43.5 per cent and a figure of 60 per cent cures in operable cases alone. These figures seem to show that as good results can be attained by irradiation as by surgery.

Jacobs, Josef. Experience in increasing the action of roentgen rays with dextrocid. *Strahlentherapie*, 1928, xxix, 403–406.

Attempts have been made to increase the sensitiveness of tumors to roentgen rays with various agents but they have not been very successful. A new one has recently been introduced called dextrocid. It is an iodine-cerium compound in 39 to 50 per cent dextrose solution. Cerium has a destructive action on malignant tumor cells and the iodine serves to carry it into the tumor. The author used dextrocid in carcinomas, lymphogranulomatoses and sarcomas. Ten c.c. was given intravenously directly before each irradiation. The solution was well borne but in most cases there was an intense general reaction one to eight hours after the irradiation so the patients should be kept in the hospital for a time. The effect of the rays was improved to such an extent that the dose could be decreased 15 to 25 per cent and the same result obtained. This prevents irritation of the skin and protects against overdosage. This is a special advantage in cases that have to be irradiated for a long time, such as lymphogranulomatosis. In carcinoma cases the smaller the tumor, the better the result. The treatment did not seem to be effective in sarcomas. The best results were obtained in cases of lymphogranulomatosis. A number of illustrative cases are described. The gland packets decreased in size more rapidly and more completely when they were treated with dextrocid before irradiation and the remissions seemed to be of longer duration. The observation time is too short to determine whether the use of dextrocid lengthens the life of the patient.

Jaroschka, K. The effect of roentgen rays on carbohydrate metabolism in carcinoma of the portio. *Strahlentherapie*, 1928, xxviii, 784–787.

Sugar determinations were made in carcinoma of the portio before any treatment at all, after the administration of grape sugar intravenously or by mouth and after roentgen treatment. After the determinations had been made following the dextrose treatment the patients were irradiated on three successive days with a dose of 650 r per field, which amounted to a deep dose in the primary tumor of about 110–120 per cent of a skin erythema dose. Then another exploratory excision was made from the tumor and the tissue tested for its sugar content. The first test before any treatment showed a greater sugar content in the tumor than in the musculature. The dextrose treatment did not cause any increase in the glycogen or sugar content of the tumor. But there was an average increase of more than a third in the sugar content of the tumor after the roentgen irradiation, no matter whether sugar had been given previously or not. The increase in sugar content was greater in tumors rich in cells than in the scirrhous forms. This increase in sugar content is brought about by an inhibition of glycolysis by the rays, possibly by a glycolytic ferment being inactivated by their action. The glycogen storage which is a necessary result of this process, brings about a disturbance of balance in the cell which helps in its destruction.

Klein, Paul. Cure of fistulas of the ureter by excluding the kidney by roentgen irradiation. *Strahlentherapie*, 1928, xxviii, 482–523.

Franz says that for implantation of the ureter into the bladder to be successful bladder, ureter and kidney must be healthy. This is never true in fistulas after the Wertheim radical operation; there are inflammatory changes in the wall of the ureter. So the only surgical method of treating these fistulas that promises success is nephrectomy. Animal experiments have shown that the function of the fistulous kidney is impaired anyway and the author's clinical cases have confirmed these findings. But these patients are in serious condition and another operation should be avoided if possible. So the author adopted the method of destroying kidney function by irradiation. Four cases are described in which this treatment was successful. Of course this

method must not be used until functional tests have shown the other kidney normal. And if there is any indication for extirpation of the kidney, such as high fever or other signs of sepsis, nephrectomy should be performed. The objection might be made that it is dangerous to leave a diseased kidney in the body but there have been no bad effects from this in any of the author's cases.

He used a symmetry apparatus, Coolidge tube, vertex tension 200 kv., parallel spark gap 49.5 ma., focus skin distance 30 cm., size of fields 6 × 8 cm. or 12 × 16 cm., depending on the habitus of the patients, filtration 0.5 mm. zinc and 0.1 mm. aluminum. The irradiations were given in one to three series. Each irradiation was given on from one to three fields, depending on the adiposity of the patient, and 90 per cent of a skin erythema dose applied to the kidney. Experience may necessitate some change in technique and dosage but at any rate the author's cases have shown that kidney function can be abolished by roentgen rays and cases of fistula cured that could not be cured in any other way except by nephrectomy.

Lahm, W. Biological cure of carcinoma. *Strahlentherapie*, 1928, xxviii, 779–783.

The author discusses just what is meant by biological cure of carcinoma. He has seen changes in the cells without any visible change in the surrounding tissue consisting of processes of maturation of the cells, hyaline mass degeneration and cell phagocytosis by carcinoma cells. He found that carcinoma of the cervix, at least in its immature forms, and adenocarcinoma, does not contain any glycogen. The capacity of the cells for storing this form of carbohydrate is lost with progressive anaplasia of the cells. Places were found in which the surface epithelium of the portio contained much glycogen while the more malignant parts that penetrated the deep tissues did not contain any. But where processes of maturation take place in immature or moderately mature carcinomas and flat cells or horny pearls develop glycogen reappears, and adenocarcinomas which form nodules of pavement epithelial cells (adenocancroids) show this phenomenon. So apparently maturation of cells, which appears in all possible variations in carcinoma, is a manifestation of a tendency to healing. A case is described in a woman of fifty-seven in which glycogen appeared after irradiation in a tumor of the ovary. As carcinoma of the ovary is a form that does not contain glycogen this proves that the differentiation of the cells brought about by irradiation is accompanied by a change in carbohydrate metabolism, a biological cell function. The eosinophilia and mass destruction of leucocytes are a part of an anaphylactic reaction, but it is questionable whether they are the cause or the effect of the anaphylaxis. The eosinophile leucocytes develop locally in the intima of the vessels; the rest of the process is to be considered a humoral one.

The author concludes that the production of general reactions is not unconditionally necessary in the biological cure of carcinoma; even the anaphylaxis spoken of above doubtless occurs at first as a purely local reaction. As carcinoma is a local disease at first it can be cured in the beginning by the use of local measures. General treatment serves to overcome the injuries to the organism that have resulted from a carcinoma that has existed for a long time.

Lahm, W. Histological observation of eight cases of carcinoma of the cervix irradiated before operation with relation to the question of recurrence and the problem of the biological cure of cancer. *Strahlentherapie*, 1928, xxx, 277–307.

The histological findings are described in detail. The regressive changes in the carcinoma cells, particularly the degeneration of the cell nuclei, are due to direct action of the rays. They never occur spontaneously to such an extent. The destruction of carcinoma tissue may produce an anaphylactic or vagotonic condition and it may reactivate embryonic properties of the connective tissue manifesting themselves as hypertrophy of the reticuloendothelial system which is important in defending the tissue from invasion by the epithelium.

From his examinations the author concludes that irradiation with about 4000 mg. radium and possibly ⅓ to ½ skin erythema dose roentgen irradiation cures tumors of the portio and crateriform ulcers. It brings about more or less complete cleansing of the tumor bed and epidermization. At the same time the true extent of the carcinoma becomes more apparent from retrogression of the infiltration in the parametria, so that it is easier to decide as to operability. Not only that but doses of this size not only bring about decrease in the size of the tumor but may even cure it if it has not reached a depth of more than 3 to 3.5 cm. Operation then serves to ensure the result. In 2 cases recurrences were seen not in the zone of weakest irradiation at the periphery of the carcinoma but in the center. This indicates that the irritation that caused the disease persisted and caused a recurrence at its original point of strongest action.

The examinations did not show anything that contraindicates preliminary irradiation. Ulcer of the vagina with granulations which Fraenkel feared did not have any bad effect in the author's cases. And the slight depth of the action of the radium, which by a supplementary dose of 330 R can be increased to 4 cm. is not a contraindication, as there was no stimulant action on the tumor, and the changes that resulted from it were favorable in prognosis. The slight signs of pelviperitonitis produced were of no consequence.

Lancashire, G. L. Roentgen therapy of skin diseases. *Strahlentherapie*, 1928, xxix, 241–244.

Experience with the roentgen treatment of skin diseases at the Dermatological Clinic of Manchester is reported. In a single year 126 cases of rodent ulcer have been treated with brilliant results. The ulcers heal without the multilation of the face which frequently occurred in the pre-roentgen era; recurrences are unusual and yield to renewed treatment. In advanced cases with involvement of the bones roentgen treatment should be combined with diathermia. Roentgen treatment is successful in chronic inflammatory conditions of the skin, especially chronic eczemas with infiltration that have become lichen-like on account of scratching, lichen planus and ordinary forms of psoriasis. In stubborn cases of acne vulgaris, specially acne indurata, roentgen therapy is often the only effective treatment, and in certain cases of acne rosacea it has given excellent results. The author has found the epilatory action of the rays valuable in many cases of sycosis barbae, though recurrences are not unusual. For many years irradiation has been used in trichophytosis of the scalp and schools and institutions kept free of the diseases in a way that was impossible before; many cases of staphylococcus infection have been cured too by roentgen epilation. The treatment has been very effective in many cases of pruritus ani and vulvae, not only in ones secondary to chronic inflammations but also in the so-called neurotic cases. In mycosis fungoides it seems to be the only method of lengthening life; one patient lived in relatively good condition for ten years. Roentgen treatment was tried in a large number of cases of lupus but in addition to the fact that the cosmetic results were not good carcinoma seemed to develop in a larger number of cases than after other treatments.

Lenart, Ernst. Good effect of roentgen rays on constipation. *Strahlentherapie*, 1928, xxviii, 598–601.

In irradiating women for tumors and other gynecological diseases the author found that the rays as a by-effect greatly benefited constipation. Some of the cases reacted better than others and they are divided into three groups with respect to the intensity of the action. In the first group the constipation was greatly improved or entirely and permanently cured by a very brief irradiation. In the second group the constipation was improved but only temporarily on the day of the irradiation or for a few days following it. In the third group the improvement was much less marked and in some cases there was very little. It is possible that the improvement is brought about by reflex stimulation of sympathetic fibers and paralysis of the sympathetic; or it may be due to increased production of cholin which causes increased peristalsis. The author thinks the chief effect is probably an action on the nerves.

Oppenheimer, R. Experience in the roentgen treatment of hypertrophy of the prostate. *Strahlentherapie*, 1928, xxix, 315–323.

Experience in the roentgen treatment of hypertrophy of the prostate shows that moderate doses of roentgen rays combined with massage of the prostate in the first stage of hypertrophy in a large number of cases decreases the signs of irritation, particularly the frequent desire to urinate and so improves the patient's subjective condition. But the treatment does not prevent the further development of the disease, particularly the occurrence of chronic retention. Irradiation of the prostate may have a good effect in prostatic hemorrhage; in acute retention small roentgen doses have no effect and in chronic retention any roentgen treatment is ineffective. The use of large doses may make a cystitis considerably worse, make operation more difficult if it is necessary to perform prostatectomy later and delay or prevent wound healing.

Palugyay, J. The roentgen treatment of male genital tuberculosis. *Strahlentherapie*, 1928, xxviii, 762–769.

Roentgen therapy is an important method in the conservative treatment of genital tuberculosis. It is best to give the irradiation in small doses, only a few per cent of the skin erythema dose, the treatments being given in a series at intervals of seven to ten days. The whole genital tract must be irradiated. With this method of irradiation after an observation period of not less than three years there have been 30 per cent clinical cures and 50 per cent improvements (the process brought to a standstill) in cases which showed quite extensive tuberculous changes. This is in marked

contrast with the less favorable or even bad results obtained with the usual high roentgen doses of 40 to 60 per cent of a skin erythema dose.

POKORNY, ADOLF, and LILLY. Roentgen treatment of hay fever. *Strablentherapie*, 1928, xxviii, 808–809.

The authors have treated 2 very severe cases of hay fever in colleagues by roentgen rays, with very brilliant results. They irradiate the nose locally: one field 6 × 6 cm. on the back of the nose with the central ray directed to the root of the nose; 25 cm. focus skin distance, 120 kv. vertex tension, universal-transverter apparatus; 4 H through 4 mm. aluminum. Both patients were immediately freed of their symptoms. One was treated in June, 1925, and had no further attacks that summer; he had mild attacks in the beginning of the season in 1926 and 1927 but they responded promptly to roentgen treatment. The authors do not know whether the effect is due to local action on the mucous membrane of the nose or to a protein body action.

SAUPE, E. Death from pulmonary embolism during an irradiation. *Strablentherapie*, 1928, xxviii, 624–626.

A patient twenty-three years of age was being irradiated for an extremely severe lymphogranulomatosis which caused such intense dyspnea that he could only be irradiated in a sitting position. He suddenly fell to the right, and before the nurse could cut off the current he had been struck by it and was dead. Autopsy showed that he had suffered a pulmonary embolism during the irradiation which had rendered him unconscious and possibly killed him before he was struck by the current. It showed that the injury by the current was not the primary one. It is questionable whether patients should be irradiated in a sitting position with the usual apparatus but it is sometimes necessary in cases of intense dyspnea if irradiation is to be given at all.

SCHMIDT, WALTER. Results of roentgen treatment of malignant tumors at the Surgical University Clinic of Göttingen from 1919 to 1927. *Strablentherapie*, 1928, xxx, 197–238.

A total of 523 malignant tumors was irradiated. From this material the author concludes that roentgen therapy cannot enter into competition with surgery in the treatment of operable malignant tumors. Operable tumors therefore should not be irradiated primarily. The only exception to this is skin carcinoma. Irradiation is given as a primary treatment in cancroid when it is multiple or when the age of the patient or cosmetic considerations make it desirable. But if a superficial skin cancer proves refractory to rays operation is performed promptly and radically. Postoperative irradiation is used in carcinoma of the breast because the percentage of cures has been increased by this method, and in all sarcomas not operated on radically and sarcomas of the trunk that have been operated on radically.

Roentgen treatment is tried in all inoperable tumors that have not caused extreme cachexia. The only exception is carcinoma of the digestive tract in which the author's experience has shown that roentgen treatment is absolutely ineffective. Irradiation of inoperable tumors is justified not only by its palliative effect but also because there have been some permanent cures in apparently hopeless cases. Local recurrences are more amenable to roentgen treatment than lymph gland and bone metastases. But irradiation is very useful in bone metastases because of its analgesic action.

SEISSER, F., and MAU, W. Results of carcinoma treatment and the relation of age to the results and to dosage. *Strablentherapie*, 1928, xxvii, 663–690.

The whole carcinoma material of the Gynecological Clinic of Magdeburg-Sudenburg from Jan. 1, 1915, up to April 1, 1924, is reviewed; 625 cases were examined to determine the final results. Carcinomas of the cervix showed 21.6 per cent absolute cures for a period of more than five years, 9.8 per cent from operation and 11.8 per cent from radiotherapy. The corresponding figures for absolute cure for carcinoma of the body of the uterus are 52.5 per cent, 30 per cent and 22.5 per cent, and for carcinomas of the ovary 20.7 per cent, 11.3 per cent and 9.4 per cent. With selection of operable cases of carcinoma of the cervix the Wertheim operation gave 61.9 per cent relative cures and irradiation of operable cases gave a figure of 43.4 per cent for relative cures, while the irradiation of inoperable and borderline cases gave 15.6 per cent relative cures. The primary mortality of the Wertheim operation was only 5.7 per cent.

The great majority of the patients were married and the frequency of carcinoma increased with increasing numbers of children, except for carcinoma of the ovary. The prognosis was in general more favorable with advancing age, both for operation and irradiation. During the age when carcinoma is most frequent, between forty and fifty, operation for carcinoma gave less favorable results than the irradiation of operable cases, contrary to what was found in the other age groups. It

was impossible to draw any definite conclusions as to prognosis and radiosensitiveness from the histological structure of the tumors.

Irradiation with mesothorium alone had just as good results as combined irradiation with mesothorium and roentgen rays. Excochleation before irradiation in carcinoma of the cervix did not make the prognosis any worse but increased the danger of fistula. After-irradiation with roentgen rays improved the results of operation considerably.

The average dose of rays for all cured carcinomas of the cervix, both operable and inoperable, was about 200 per cent of the skin erythema dose for the middle critical zone. The dose decreased gradually from 275 per cent of the skin erythema dose at thirty years of age to about 125 per cent at seventy. The average dose for cured carcinomas of the body of the uterus was about 120 per cent of the skin erythema dose.

Bauereisen, A. Remarks on the work of Seisser and Mau on carcinoma treatment. *Strahlentherapie*, 1928, xxvii, 691–693.

The author, who is the chief of the Magdeburg–Sudenburg Gynecological Clinic comments on the article of Seisser and Mau (see abstract above) on the results of carcinoma treatment at that clinic. He says that the advocates of radiotherapy alone think it is contradictory to irradiate only inoperable cases and reserve the good cases for operation. But he sees nothing illogical in this procedure as long as there are organs in which carcinoma reacts poorly or not at all to roentgen and radium rays and as long as it is impossible to tell whether a carcinoma in a given organ will react well or poorly to irradiation. And he does not think that the objection that operation has a high mortality is any longer valid when the mortality of the Wertheim operation has been reduced to so low a figure.

He thinks that preliminary radium irradiation is indicated in suitable cases of carcinoma of the cervix and portio but he does not think it should be used as a routine treatment as it sometimes renders later operation difficult. But he thinks excochleation and coagulation or cauterization very useful before either operation or irradiation. It limits secondary secretion and hemorrhage; it is not yet known whether it has a particularly good effect on the permanent results.

It is hard to determine the correct dose and either too large or too small a dose does harm; he thinks the average doses given by Seisser and Mau are about right.

An effort should be made to teach the public that cancer is at first a local disease and can be cured by proper treatment at this stage. The treatment of cancer should be made a matter for government support and supervision, just like the care of infants, prevention of tuberculosis and the treatment and supervision of sexual diseases.

Sgalitzer, Max. Roentgen treatment of acute recurrence in chronic osteomyelitis. *Strahlentherapie*, 1928, xxix, 311–314.

A case is described in a patient of thirty-one which illustrates the extraordinarily good effect of roentgen treatment with very weak irradiation, about 15 per cent of the skin erythema dose, in acute recurrence of chronic osteomyelitis in which no sequestrum has yet been formed. The duration of the disease is generally reduced to a few days. This treatment has been used in 48 cases with very rapid improvement in all of them. They were the kind of cases in which the patient is ordinarily kept in bed for weeks by such recurrences.

Simons, A. Radiotherapy of sarcoma of the tongue. *Strahlentherapie*, 1928, xxix, 122–127.

A case of interstitial lymphosarcoma of the posterior part of the tongue with swelling of the glands in the left submaxillary region is described which was cured by roentgen and radium treatment and has remained free of recurrence for six and a half years. Radical operation has heretofore been considered the treatment of choice in this unusual localization of tumor. But from recent literature it would seem that in certain cases irradiation alone or in combination with less radical, non-mutilating operation is to be preferred. The points that decide in favor of surgery or irradiation in the individual case are the histological nature of the tumor and its form, size and extent.

Stein, R. O. What kind of condylomata should be treated with roentgen rays? *Strahlentherapie*, 1928, xxix, 263–267.

From his experience in this field the author has found that rapidly growing, cauliflower-like, moist condylomata react well to roentgen irradiation. They are the ones that are hard to remove surgically on account of copious hemorrhage and extensive postoperative scar formation; their removal was particularly difficult in pregnant women. But small pointed condylomata, occurring sometimes alone, sometimes in groups, proved quite resistant to the rays so it is best to continue to remove them surgically.

Störmer, A., and Gotthardt, P. P. Roentgen treatment of brain tumors. *Strablentberapie*, 1928, xxix, 678–697.

A material of 34 cases is reported with an improvement bordering on cure in 29 per cent, permanent improvement in 20 per cent and in the other cases either only slight temporary improvement or none at all. Gliomas rich in cells give the best results; fibrillary gliomas, fibromas, neuromas and endotheliomas do not react so well, as would be expected from their structure. The rays act on glioma cells. Tumors of the cerebellum seem to react best. Operable tumors should be operated on; operation may be preceded by a series of test irradiations if there are no serious signs of brain pressure. Inoperable tumors should be irradiated. The tumor may be inoperable on account of its size or because it cannot be localized. Trephine should be performed only in case of necessity. The results of irradiation are not any worse than those of surgery. Irradiation is given through 4 or 5 fields; about 100 per cent of the skin erythema dose should be applied to the tumor. The irradiation must be continued for a long time for fear of recurrences that cannot be affected by rays.

Stuhmer, A. Roentgen treatment of skin diseases. *Strablentberapie*, 1928, xxix, 469–482.

From a review of the work in the treatment of skin diseases the author comes to the conclusion that such treatment should be undertaken only by skilled specialists in dermatology. Clinical control of each individual case before every irradiation is necessary so no routine method of giving series of irradiations should be practiced. Roentgen irradiation of the skin differs from all other methods of treatment in the fact that for a given area of skin only a certain dose can be given in the whole life of the patient so the physician should be as economical as possible in the use of the method. It is a mistake to use irradiation alone in skin diseases which are amenable to medical treatment. The long after-effect of roentgen irradiation makes caution particularly necessary. Recurrences on skin that has been irradiated before are generally very resistant to treatment. The indications as to time, quality of rays and dosage must be determined very accurately. Roentgen rays have been declared legally to be a "severe toxin." So roentgen irradiation is a serious matter and should be represented to the patient as such.

Roentgen irradiation should not be used as a treatment for inflammation in acute dermatoses. With careful dosage unfiltered rays can be used. The dosage should be given in percentages of the skin erythema dose; if the apparatus in all institutions were accurately adjusted to 100 per cent skin erythema dose then really comparable reports of dosage could be made. It will require experience to show what percentages are the minimum of effective irradiation in the different dermatoses. Series of irradiations should be stopped if the desired result is obtained or in immediate prospect. While individualization is necessary, the rule of three series with an interval of ten days between irradiations should be followed in a general way. Irradiation in fractional doses and at irregular intervals should be avoided.

Thedering, Franz. Finsen and roentgen light in the treatment of lupus. *Strablentberapie*, 1928, xxix, 274–282.

The author refers to the work of Reyn in which he urgently advises against the use of roentgen rays in lupus and advocates the use of Finsen light alone. Thedering also thinks Finsen treatment is valuable but secondary to roentgen treatment for two reasons. In the first place the nature of the lesions in lupus has changed in recent years. There is less of the nodular lupus in which Finsen light is particularly effective and more of the connective tissue (scrofuloderma) and glandular forms. In the second place, physicians in Germany are not able to keep their patients under treatment for so long as is necessary in the Finsen method but must adopt a quicker method.

The author has had excellent results from a combined quartz lamp, copper and roentgen method. He agrees with Reyn that the Kromayer lamp alone does not have a sufficient deep action but this action can be supplemented by the use of copper and roentgen rays. The area is first irradiated with the Kromayer lamp and then an organic copper salve applied. The method is painful but most patients can stand the copper dressing for six to twelve hours a day and that is enough. Then the skin can be dressed with boric acid salve and the copper applied again the next day. This brings about an active leucocytosis. But even this does not produce a sufficient deep action so it is supplemented by roentgen irradiation. The whole point in avoiding injury lies in the dosage. In chronic inflammatory diseases of the skin small doses of rays frequently repeated are indicated. The individual dose with varying tension and filtration is 0.1 to 0.5, or at most and rarely 1.0 X, measured by the Kienböck and Sabouraud method. This dose is repeated once a week or twice a month. Needless to say there is no danger of roentgen injury of the skin with this dosage.

In addition to this combined method the roentgen full bath with the rays applied to the spleen is now being found valuable in the treatment of lupus. The author intends to publish a full report of this new technique later.

WAGNER, G. A. Roentgen therapy of genital tuberculosis in women. *Strablentherapie*, 1928, xxviii, 759–761.

At the Prague Gynecological Clinic 42 cases of genital tuberculosis in women have been treated by roentgen irradiation from 1921–1927. In the first group of 14 cases the genital tuberculosis was associated with an ascitic form of peritoneal tuberculosis. In this group only 3 cases were completely successful, 5 quite satisfactory and 3 unsatisfactory; 3 of the patients died of tuberculosis of other organs. In the second group of 18 in which there was no ascitic peritoneal tuberculosis, the results were satisfactory in 16 and the other two have only been under treatment a short time. The third group included two cases with tumor-like tuberculosis of the portio; one of these patients was cured; the other had to be operated on later. The fourth group included 7 cases in which the tuberculous nature of the disease of the adnexa was only discovered on operation and, they were irradiated afterward. They were all cured.

The dosage given the first two years, 30–50 per cent of a skin erythema dose, was found too high and better results have been obtained since with a dose of 10–15 per cent of a skin erythema dose. The irradiations were repeated after intervals of four weeks to several months. There are no real contraindications to the use of roentgen therapy in tuberculosis. Differential diagnosis from other diseases of the adnexa is sometimes difficult but this is not a serious matter as weak roentgen irradiation is indicated in all chronic inflammatory conditions of the adnexa. If there are large tumors containing caseous pus they should be evacuated before roentgen irradiation is given. In all of the 42 cases mentioned above tuberculosis was definitely demonstrated. In view of the good results from roentgen treatment the author no longer uses surgery in tuberculosis of the adnexa at all; even if operation has been begun and the disease is found to be tuberculosis, the abdomen is closed and treatment continued with roentgen rays.

MISCELLANEOUS

BASS, F., and JAROSCHKA, K. Increased resistance to streptococcus sepsis brought about by roentgen irradiation in animal experiment. *Strablentherapie*, 1928, xxviii, 568–580.

Rabbits were given intravenous injections of 0.5 to 1 c.c. of a twenty-four hour ascites bouillon culture of a virulent strain of hemolytic streptococcus from which the non-irradiated animals died in one to four days. Some of the animals were irradiated twelve to fourteen hours before the injections, with a symmetry apparatus, Coolidge tube, type C. T. II with a vertex tension of 200 kv., parallel spark gap 49 cm., 3 ma., filtration 0.5 zinc and 1 mm. aluminum with a focus skin distance of 40 cm. With a deep action of 29 per cent at a depth of 10 cm. about 325 to 350 R was given, corresponding to a skin dose of 5–6 H.

A typical protocol is given. In this and the other experiments the resistance was considerably increased by the irradiation. While the control animals died in one to four days the irradiated animals survived five to fourteen days and up until about three days before death showed no symptoms. There were many more streptococci in the blood and organs of the control animals than of the irradiated ones and in one of the irradiated ones there were none at all. It seems possible that by irradiating at the proper time and experimenting with dosage, better results can be obtained in human streptococcus infection than have been so far. It seems probable that the increased resistance is due to activation of the total reticulo-endothelium of the body from the irradiated part. The finer mechanism of the action is not clear.

BEHNKEN, HERMANN. The question of the unit of roentgen dosage. *Strablentherapie*, 1928, xxix, 192–198.

Glasser and Meyer from a number of comparative measurements with German and American dosimeters and from differences in the reports of erythema doses by German and American authors concluded that the German unit of dosage is as much as 40 per cent larger than the American one. In order to compare the German and American units the author, who works in the Reichsanstalt in Berlin, had two special dosimeters made which he called the first and second American apparatus (AG I and AG II), designed to carry the unit from Germany to American and back again. They were gauged in the Reichsanstalt with the air pressure chamber for a number of different qualities of rays. Jaeger first took the AG I to Bonn and compared it with the standard there; the author took AG II to Göttingen and Hamburg and made the comparisons. Then the author took both to America and compared his measurements with those of Glasser in Cleveland and Duane in Cambridge, Mass. Then they were brought back to Germany and

gauged at the Reichsanstalt. Tables are given showing the details of the results. They show complete agreement between the Reichsanstalt and Bonn and probably complete agreement between the Reichsanstalt and Cambridge; between the Reichsanstalt and Cleveland there are variations of about 4 per cent. There are variations of about the same degree between the Reichstanstalt and Göttingen and Hamburg. Though these variations are not great enough to be of much practical importance, the author is making efforts to explain and if possible overcome them. He cannot explain the great differences found by Glasser but they evidently were not founded in the nature of the unit but developed in the course of transportation from Germany to America. The measurements described here show that it is possible to reproduce the R unit at different points on the earth's surface with sufficient accuracy for practical purposes.

SOLOMON, I. Comparative study of two dosimetric roentgen units, the French R (Solomon) and the German R (Behnken). *Strablentherapie*, 1928, xxix, 199–200.

Murdoch and Stahel criticize the French R and say that it can never be used as an absolute unit, but Solomon says that the discrepancies reported by these authors can easily be explained from the fact that they used chambers that are dependent on wave length. With the use of ionization chambers that are independent of wave length such discrepancies as those reported by these authors do not occur and the mistaken conclusions they drew can be avoided.

BEHNKEN, H. Reply to Solomon's note on the French unit. *Strablentherapie*, 1928, xxix, 201–202.

Solomon criticizes the findings of Murdoch and Stahel as being based on the results from a chamber dependent on wave length. But that is the very weakness of the Solomon unit; it is almost impossible to construct a small chamber that is completely independent of wave length. And the independence of wave length of even the best small chamber is limited on the long wave side by unavoidable absorption by the wall of the chamber. Fricke-Glasser's independence of wave length, strictly speaking, only holds good of a chamber with infinitely thin walls. So there is a limit in the direction of long waves beyond which Solomon's R cannot be used as a unit of dosage, while the German unit holds good for rays of any softness. On the whole, the objection of Murdoch and Stahel that the Solomon unit is not an absolute unit is true and the gauging of small chambers must be carried out with the aid of large standard chambers for different qualities of rays.

BUCHER, O. H. Serum examinations of the catabolic capacity of cancer patients and the changes brought about in it by roentgen rays. *Strablentherapie*, 1928, xxix, 71–107.

Herzfeld and Klinger reported a cancer reaction based on the digestion of cancer cells by the serum of cancer patients. The author tested this reaction and also the effect of roentgen irradiation on the digestive capacity of cancer serum. In agreement with Schinz and Germann he found that there is no characteristic difference between carcinoma patients and normal individuals in the capacity of their serum for digesting cancer cells. Catabolism experiments on cancer patients by the Herzfeld-Klinger method showed a digestive capacity of more than 10 mg. in 75 per cent of the cases (amino-acid content per 100 c.c. serum, expressed in milligrams glycocoll), the boundary for digestive capacity in carcinoma lying at 10 mg. That is, 75 per cent of patients definitely proved to be cancerous had the same digestive capacity as ones free of cancer. The average digestive capacity of the cancer patients examined by the author before irradiation was 15.35 mg., after irradiation 14.13 mg., the average for noncarcinomatous patients was 17.25 mg. amino acids. No increase of the digestive capacity of the serum on carcinomatous tissue could be demonstrated as a result of the action of roentgen rays. Both cancer patients and normal individuals show great variations in the digestive capacity of their serum both before and after irradiation. Individuals who for four years had been clinically free of cancer sometimes showed a digestive capacity of their serum lying within the range of the values reported by Herzfeld-Klinger for cancer; sometimes they digested like normal individuals, that is, more than 15 mg. glycocoll. Catabolic capacity is not in proportion to serum autolysis. There is often a reciprocal relation between digestive capacity and refraction of the serum both in normal individuals and cancer patients, the catabolic capacity rising with falling value for refraction, but the author's examinations did not show that this is a constant rule. Further experiments will have to be made to test this point.